SEEING *ISN'T* BELIEVING
The science of optical illusions

IMMUNE TO HIV
Meet the people who could save the world

JURASSIC WORLD
How new fossils mess up our movies

AUSTRALIAN

SCIENCE ILLUSTRATED

YOU ARE HERE

INCREDIBLE NEW PICTURES!

OUR PLACE IN SPACE

AMAZING **NEW OBSERVATIONS** SHOW EXACTLY WHERE WE STAND IN AN INFINITE UNIVERSE

RISE OF THE MACHINES
Robots that mimic humans. What could go wrong?

ADDICTED TO ADRENALIN
Why some of us jump out of planes for no reason

ISSUE #37
SCIENCEILLUSTRATED.COM.AU

PLUS! WHO'S YOUR FISH DADDY? // EVERYTHING YOU NEED TO KNOW ABOUT LIGHT // LOOK OUT! SCORPIONS! // AMAZING SUPERNOVA PICS

THULE SWEDEN

› Rock solid design

NEW

Thule Vectros

Protective bumper for MacBook®

Keep your MacBook safe! Thule Vectros bumper is a lightweight protective case with shock-absorbing design, protecting your MacBook from bumps and drops up to *1 meter*. Tried and tested, it is engineered to offer ultimate protection while maintaining the sleek design for carrying convenience.

Available for MacBook Air® and MacBook Pro Retina®.

Available from:

JB HI-FI

good get .com.au

Bring your life
thule.com

SCIENCE ILLUSTRATED

Issue #37 (18th June 2015)

EDITORIAL
Editor Anthony Fordham
afordham@nextmedia.com.au

DESIGN
Group Art Director Kristian Hagen
Art Director Malcolm Campbell

ADVERTISING
National Advertising Executive
Lewis Preece lpreece@nextmedia.com.au
ph: 02 9901 6175
Divisional Manager
Jim Preece jpreece@nextmedia.com.au
ph: 02 9901 6150

Production Manager Peter Ryman
Circulation Director Carole Jones

INTERNATIONAL EDITION
Editor-in-Chief Sebastian Relster
International Editor Lotte Juul Nielsen

BONNIER INTERNATIONAL MAGAZINES
International Licensing Director
Amy Mangino
Art Director Hanne Bo
Picture Editors Allan Baggesø,
Lisbeth Brünnich, Peter Eberhardt

nextmedia

NEXTMEDIA
Chief Executive Officer David Gardiner
Commercial Director Bruce Duncan

Science Illustrated is published
7 times a year by nextmedia Pty Ltd
ACN: 128 805 970
Building A, 207 Pacific Highway
St Leonards, NSW 2065

www.scienceillustrated.com.au

To subscribe, call 1300 361 146 or 9901 6111 or visit mymagazines.com.au

THE SCIENCE ILLUSTRATED CREDO
We share with our readers a fascination with science, technology, nature, culture and archaeology, and believe that through education about our past, present and future, we can make the world a better place.

Don't Let Facts Ruin a Good Story!

Hollywood has made dinosaur movies for, well, pretty much its entire history. And why not? Just chuck a few boys and gals back in time, or onto a long-lost island, and the giant lizards add instant drama.

Lizards? Indeed, when the first proper dinosaur movie came out - 1925's *The Lost World* - most people still thought dinosaurs were lizards. Green, scaly lizards. And when that changed, later films didn't care.

One of the first dino movies I was a fan of was 1985's *Baby*. In it, a palaeontologist and her husband end up protecting a baby *Brontosaurus* from an evil poacher. Since then, the *Brontosaurus* has been made obsolete (thought instead to be a kind of *Apatosaurus*) and, just this year, brought back as a distinct species, though not with universal scientific support.

Meanwhile: *Jurassic Park*. When the first film came out in 1993, an early scene showed a *Brachiosaurus* rearing up on its hind legs to grab leaves. Subsequent research has shown the *Brachiosaurus* couldn't do this (though the film did get it "right" that the dinosaur was probably warm blooded).

Because until now, the Jurassic Park franchise has always tried to meld scientific accuracy with its 12-year-old-computer-hacker and post-apocalyptic theme park shenanigans. Yet it seems the latest discoveries about the average dinosaur's external appearance is just too much science for Hollywood.

There's mounting evidence that many iconic species - especially *Velociraptor* and *Tyrannosaurus rex* - had feathers. Maybe just as babies, maybe only at certain times during their evolution, the debate rages on.

Much to the Internet's meme-based amusement, the director of *Jurassic World*, Colin Trevorrow, tweeted: "No feathers. #JP4." It seems giving the dinos fluffy bits was just too much for an entertainment business with billions invested in classic-style saurian action figures.

Do we know for sure that any of these dinosaurs had feathers, or feather-like covering? Just three years after *Jurassic Park* hit cinemas, palaeontologists published studies saying *Sinosauropteryx* (a small Chinese therapod) had fuzzy primitive almost-feathers. Today, because of the range of dinos that show evidence of feathers in their fossils, and our understanding of how those dinos are related to some of our movie favourites, there's as much evidence-by-inference that *Tyrannosaurus rex* had feathers, as there is that the earliest humans had hair.

It's okay. We understand. Hollywood is a deeply conservative place. The risk of spending $300 million on a movie only to have people say "ha ha those feathered dinosaurs look stupid" is just too huge.

But Hollywood is also full of surprises. The original *Jurassic Park* was the first film to depict dinosaurs as fast, smart, alert hunters instead of lumbering Godzilla-style monsters. Who knows: maybe a visionary (and possibly slightly nuts) director will stake his career on a "properly accurate" dinosaur movie again one day.

After all, a shaved tiger is marginally less terrifying than a fully-furred one. The same should be true of *T. rex*.

Anthony Fordham

Twitter: @sci_illustrated

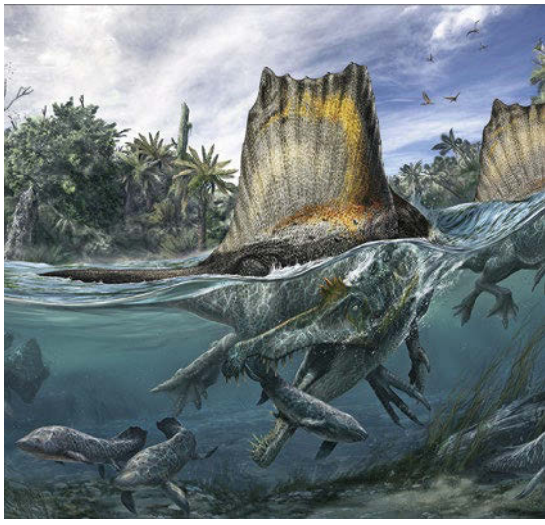
Facebook: facebook.com/ScienceIllustratedAus

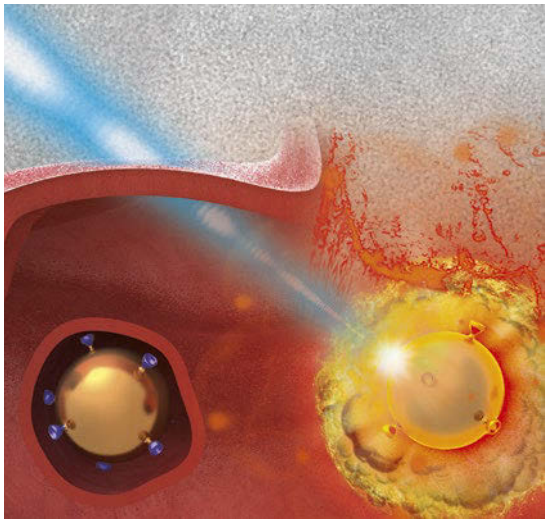
THINGS WE LEARNED IN THIS ISSUE

+ We live in a **GALACTIC SUPERCLUSTER** with a name that means limitless heaven
+ You can't trust **YOUR BRAIN** to interpret what your eyes see correctly - ever!
+ Many of the best **DINOSAUR WEAPONS** are found on non-predator species!
+ There's a **DISEMBODIED ROBOT MOUTH** that is pretty much the creepiest thing ever
+ Being **ADDICTED TO ADRENALIN** is chemically like being addicted to cocaine.

CONTENTS

ISSUE #37 | SCIENCE ILLUSTRATED AUSTRALIAN EDITION
PUBLISHED 18TH JUNE 2015





FISH FATHER INCUBATES EGGS IN HIS MOUTH

Life as a single parent can be a lot to swallow – particularly for a cardinalfish. The female just lays her eggs beside the male, leaving the rest up to him. To protect the offspring against predators, the male draws all the eggs in his mouth as soon as he has fertilised them. Until the eggs hatch, he is unable to eat – apart from the eggs that he accidentally swallows during brooding. Light organs full of luminous bacteria make the cardinalfish glow.

MARCELLO DI FRANCESCO

FROM DESTRUCTION COMES BEAUTY

Two stars used to orbit each other in a binary system, but now, only one remains: the dot in this huge stellar nebula. The Hubble space telescope took this amazing image of this supernova remnant. The surviving star stole hydrogen from its companion, an ageing massive star. When enough hydrogen had been swallowed, the massive star collapsed, triggering an explosion that shone for days.

NASA

Editors: Julie Hjerl Hansen

SHUTTERSTOCK & CLAUS LUNAU

EARTH'S INNER CORE... HAS ITS OWN CORE

By studying earthquake waves travelling through Earth's interior, scientists have made a ground-breaking discovery: Earth's inner core has two layers.

GEOLOGY Scientists know more about remote planets such as Mars and Jupiter than about the inner core of our own world. But now, a new technique allows geologists to use ultrasound to study Earth's interior in the same way as doctors look into patients.

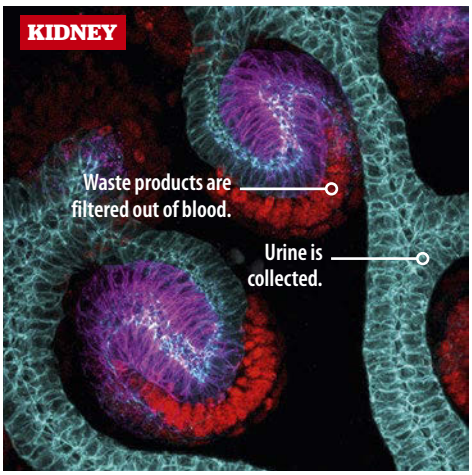
Using the new method, geologists from the US University of Illinois and China's Nanjing University have made a ground-breaking discovery: Earth's inner core is not the innermost – there is a second core. The scientists scanned Earth's interior by means of seismic waves from earthquakes, which travel all the way through Earth to the core and back. They discovered that the iron particles of the outer inner core are organised in a north-south direction, but in the inner inner core, they point east-west.

Armed with the new knowledge, scientists hope to learn more about how Earth developed and how Earth's core interacts with the global magnetic field, which functions like a shield, protecting us against radiation from space.

▶NEWS FLASH!

THIRST SWITCH FOUND IN MICE BRAINS

Scientists have located the groups of brain cells that activate the feeling of thirst in mice. Using laser, the scientists were able to activate the brain cells and make the mice drink, though they were not thirsty.



NILS LINDSTRÖM/UNIVERSITY OF EDINBURGH

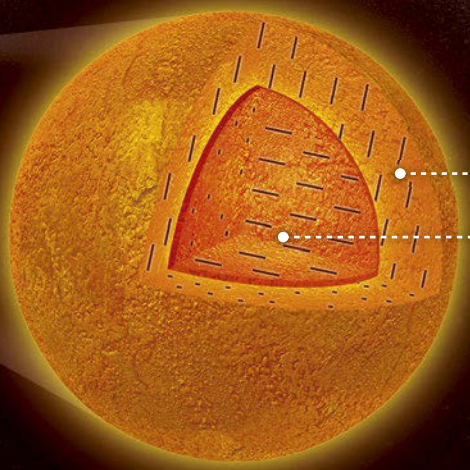
Video reveals how cells develop into a functional mouse kidney.

VIDEO REVEALS THE FORMATION OF A KIDNEY

MEDICINE Thanks to ground-breaking new video, scientists are now able to watch cells develop into a complex organ.

The process is like a tree branching out as it forms. A team of scientists from the University of Edinburgh in Scotland have used extremely detailed recordings to document the development of a mouse kidney step by step. The video reveals that a molecule by the name of beta-catenin plays a key role. The molecule instructs the cells to produce specialised structures inside the kidney. In this way, millions of tubular units known as nephrons are created, which produce urine by filtering toxins out of the blood.

300,000 years before Homo sapiens first roamed the Earth, Homo erectus mastered the art of decorating sea shells.



Different inner cores

The outer inner core, in which the iron particles are organized north-south.

The inner inner core, in which the iron crystals are organized east-west.

Pole reversal may have triggered the explosion of life

The discovery of Earth's inner-inner core, in which iron crystals point in a different direction than in the outer-inner core, supports the theory about the poles switching places some 0.5 billion years ago. The pole reversal coincided with the Cambrian explosion, in which almost all modern animals evolved over a period of only 10 million years. What set off the explosion of life remains a huge scientific mystery, but the pole reversal may be a clue.

DADEROT

530 million years ago, multicellular organisms such as trilobites suddenly appeared – perhaps due to pole reversal.

BAHAMAS HUMMING BIRD IS ITS OWN SPECIES

Until 2015, scientists considered the Calliphlox lyrura humming bird from the Bahamas to be a subspecies of the Bahama woodstar. But after studying the appearance, sounds, and DNA of the small bird in greater detail, US scientists have concluded that the bird is its own species. So, now there are two species of tiny birds with long, thin beaks in the Bahamas.

ANAND VARMA

1. Washing is sorted out.

2. It is carried to the machine.

3. The machine is loaded.

ROBOT DOES THE LAUNDRY

TECHNOLOGY While a robot teaching itself how to cook has still not been developed, scientists from the American University of California have managed to programme a robot to master another household task: laundry. Known as PR2, the robot was previously taught how to set a table, get beer from the fridge, and fold clothes, and now it can do the laundry. For humans, this is an easy task, but for a robot, the process is complex, as it involves unknown factors – for instance, the robot must figure out when to get dirty clothes from the basket and when the washing machine is full.

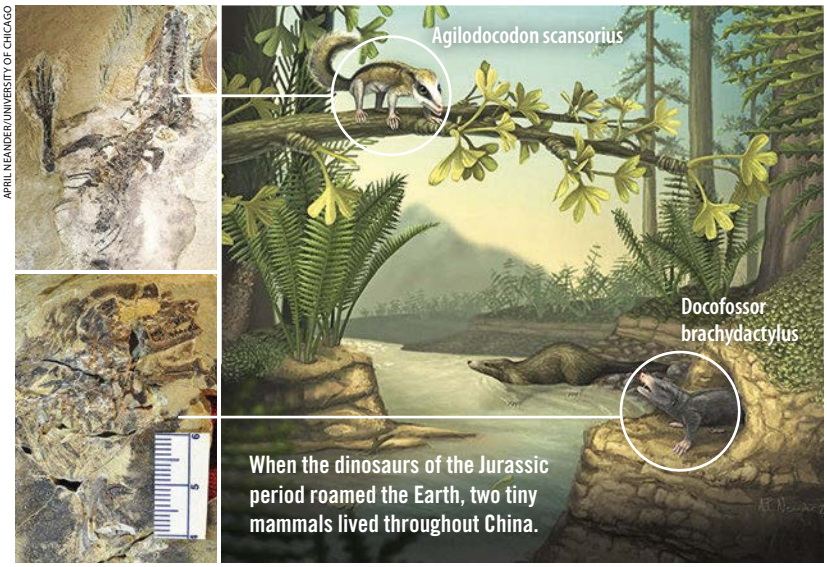
SIDDARTH SRIVASTAVA

20 is the number of times an innovative type of paper can be overwritten without losing colour nor contrast. It was developed by US scientists.

Miniature mammals lived side by side with dinosaurs

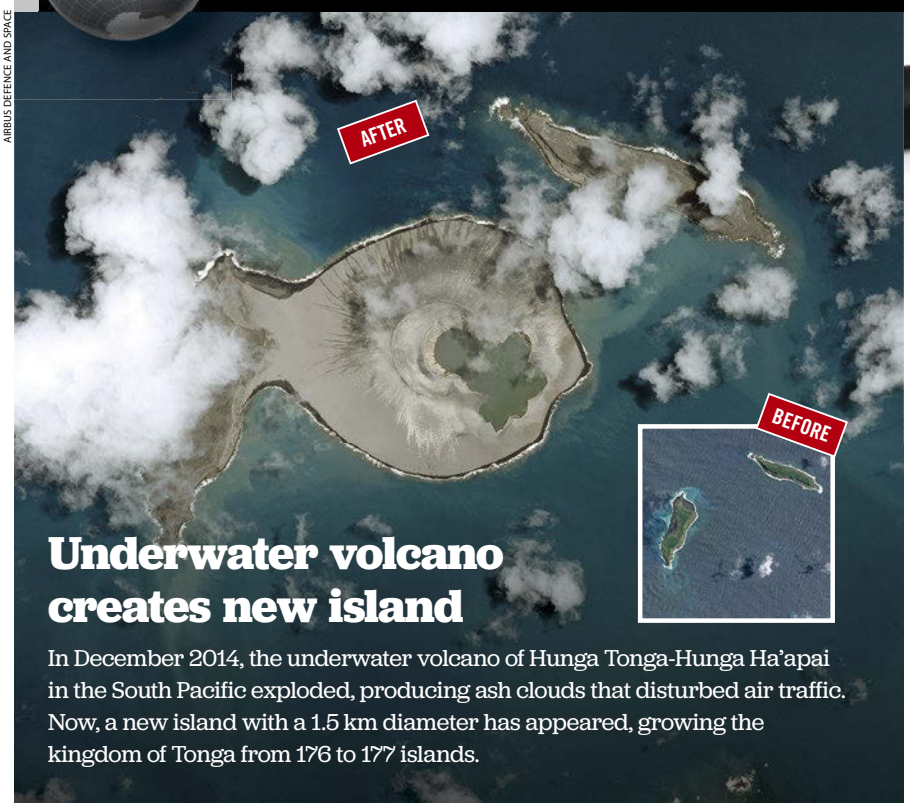
PALAEONTOLOGY In China, scientists have found fossils of two small mammals that lived side by side with the dinosaurs some 160 million years ago. The newly discovered mammals resemble modern rodents and were the size of mice.

The two animals lived in two very different environments. One of them, Agilodocodon scansorius, hung out in tree tops and is the oldest known tree-dwelling mammal. The animal was good at climbing, with long claws and powerful teeth that could gnaw in bark. The other animal, Docofossor brachydactylus, was a tiny cave dweller with a body designed for squeezing through narrow passages and shovel-shaped forelimbs designed for digging. The animal is the oldest known mammal that lived below the ground. Both newly discovered creatures belong to the Docodonta order of extinct mammals that share their ancestors with modern mammals.



APRIL NEANDER/UNIVERSITY OF CHICAGO

LOCAL FOCAL POINT
South Pacific



AIRBUS DEFENCE AND SPACE

Underwater volcano creates new island

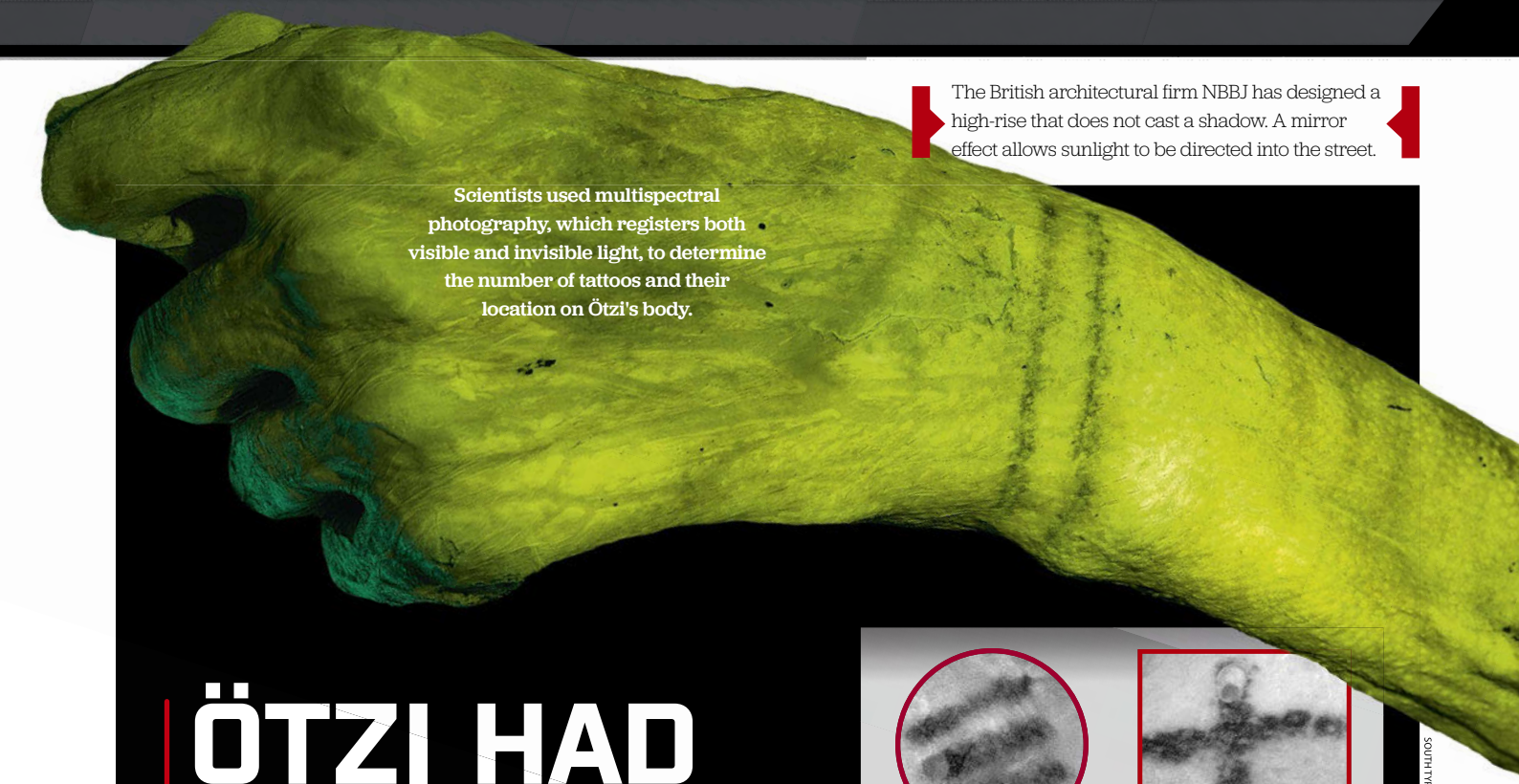
In December 2014, the underwater volcano of Hunga Tonga-Hunga Ha'apai in the South Pacific exploded, producing ash clouds that disturbed air traffic. Now, a new island with a 1.5 km diameter has appeared, growing the kingdom of Tonga from 176 to 177 islands.

SHUTTERSTOCK

E-CIGARETTES INCREASE RISK OF LUNG INFECTION

Popular e-cigarettes with nicotine are not harmless, according to new scientific research by the US John Hopkins Bloomberg School of Public Health. Mouse experiments have revealed that their lungs are harmed by nicotine inhalation. Mice exposed to nicotine vapours suffered a greater risk of developing lung infections such as pneumonia than mice that had not inhaled nicotine.

The British architectural firm NBBJ has designed a high-rise that does not cast a shadow. A mirror effect allows sunlight to be directed into the street.



Scientists used multispectral photography, which registers both visible and invisible light, to determine the number of tattoos and their location on Ötzi's body.

ÖTZI HAD 61 TATTOOS

Sophisticated image technology reveals that the 5,000+-year-old Ötzi the Iceman had tattoos all over his body.

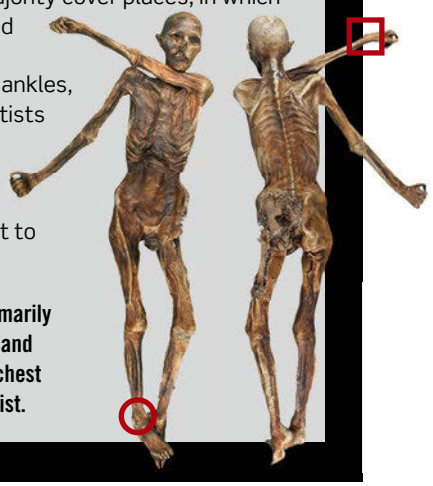
ARCHAEOLOGY Ötzi the Iceman continues to surprise scientists. Since the body of the 5,000-year-old man was found in the ice of the Ötztal Alps in 1991, he has been studied using a wealth of techniques. Now, a new study reveals that the ice man liked body art. Ötzi's skin has shrunk and is discoloured after all the years in the snow, so his tattoos cannot be seen with the naked eye. But by means of a special imaging technique, scientists from the archaeological museum of South Tirol have found no fewer than 61 tattoos on Ötzi's mummified body.

The tattoos primarily cover his lower legs, back, and chest. Organized in groups of 2-3 units, they were made using a primitive technique, by which soot was rubbed into small, deep cuts, so the colour entered deep into the skin.

SOUTH TYROL MUSEUM OF ARCHAEOLOGY

Healing tattoos

Ötzi's tattoos are made up by vertical and horizontal lines and look like a type of bar codes. The vast majority cover places, in which the iceman suffered osteoarthritis – particularly knees, ankles, and loins. So, scientists assume that the tattoos were a type of acupuncture meant to relieve the pain.



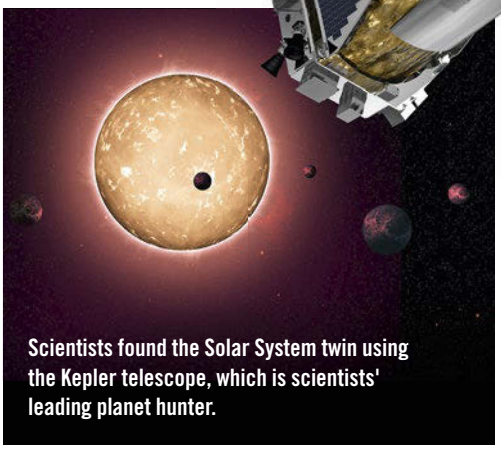
The 61 tattoos are primarily located on Ötzi's legs and back, but also on his chest and around his left wrist.

SHUTTERSTOCK

SUNFISH SUNBATHE BEFORE DEEP DIVES

ZOOLOGY Scientists have long wondered why ocean sunfish spend about half of their time floating near the ocean surface. Now, scientists from the University of Tokyo have solved the mystery: This huge 3-m-tall fish that weighs several tonnes, is simply sunbathing to get warm before and after diving into the cold abyss, where the fish collects its preferred food, marine hydrozeans, 100-200 metres below the surface.

Toxin from spiders may be included in future painkillers, according to the results of new research. Some types of spider toxin blocks out signals from nerves to the brain.



TIAGO CAMPANTE/PETER DEVINE & NASA

Scientists found the Solar System twin using the Kepler telescope, which is scientists' leading planet hunter.

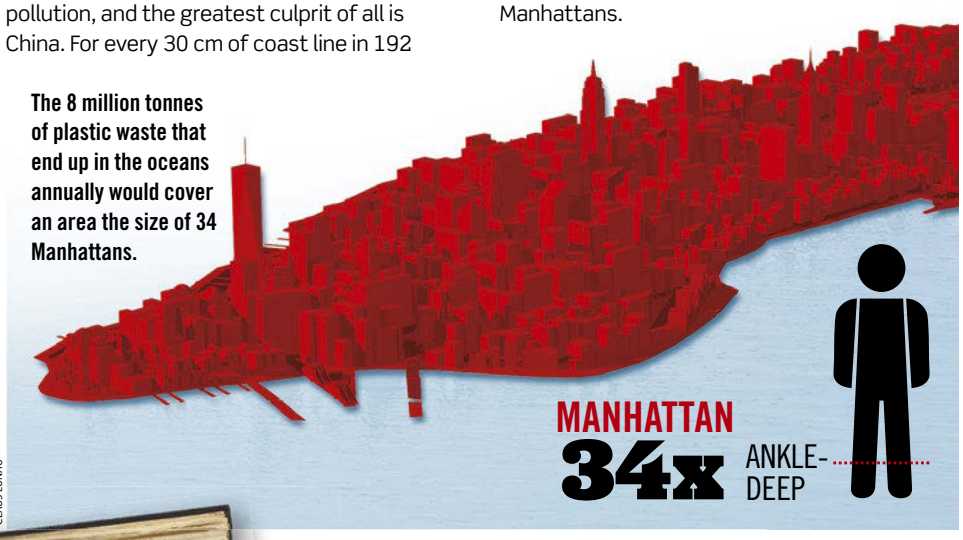
KEPLER HAS FOUND SOLAR SYSTEM TWIN

ASTRONOMY Some 117 light years from Earth, there is a solar system which looks just like ours. The system consists of five planets that all orbit closely around a solar-like star, Kepler-444. By all accounts, the planets are rocky planets like Earth.

Kepler-444 was formed in the early universe 11.2 billion years ago and so, it is 2.5 times older than Earth. Scientists from the British University of Birmingham made the discovery of the Solar System twin.

THE OCEANS ARE FULL OF PLASTIC

ENVIRONMENT Every year, eight million tonnes of plastic end up in the oceans, according to an analysis made by scientists from the US University of California, Santa Barbara. Only 20 countries are responsible for 83 % of the pollution, and the greatest culprit of all is China. For every 30 cm of coast line in 192 countries bordering on oceans, the equivalent of five shopping bags of plastic are dumped into the water. If all the plastic that ends up in the oceans annually were collected, it would cover an ankle-deep area the size of 34 Manhattans.



The 8 million tonnes of plastic waste that end up in the oceans annually would cover an area the size of 34 Manhattans.

CLAUS LUNAU

STRANGE – BUT TRUE!

Dinosaurs ate fungi

Encapsulated in amber, scientists have found a 100 million-year-old leaf of grass with traces of an euphoriant fungus which can cause hallucinations. According to the scientists, dinosaurs ate the fungi, but they do not know the effect on the beasts. We're guessing epic trips.

Hearing-impaired listen with tongues

American scientists have invented a device that can help deaf people. A mike takes in words, that are subsequently converted into waveforms, which stimulate the owner of the device's tongue.

FREEDOM CHARTER FROM THE 1300S MISLAID IN NOTEBOOK

Archaeologists are thrilled to have found an original version of the English Magna Carta freedom charter from 1300 in a notebook in South East England. First completed in 1215, the Magna Carta was epoch-making as it determined that anyone – including the king – was subject to the law.

NEWS FLASH!

BIONIC CONTACTS ENHANCE VISION

Swiss scientists have developed a set of contact lenses that can zoom, as the owner of the lenses winks.

A THINK INC EVENT

AN EVENING WITH

DR NEIL DEGRASSE TYSON

HOST OF

COSMOS

A SPACETIME ODYSSEY

7 AUG **MELBOURNE MCEC**

16 AUG **BRISBANE COURIER-MAIL PIAZZA**

22 AUG **SYDNEY HORDON PAVILLION**

23 AUG **CANBERRA LLEWELLYN HALL**

TICKETS AVAILABLE AT
WWW.THINKINC.ORG.AU

Ri Aus · Popular Science · Science Illustrated · National Geographic Channel · anusa · UNSW Australia · Ticketek · THINK INC

200 years is how old a bowhead whale can grow. So, scientists have sequenced the whale's genome, hoping to make people live longer.

WASP USES VIRUS TO BRAINWASH LADYBUG

Biological warfare is parasitic wasp's efficient weapon.

BIOLOGY Dinocampus coccinellae, a parasitic wasp, is infamous for its ability to convert ladybugs into zombies. So far, scientists have been unable to figure out how the wasp does it, but now, a French-Canadian team of scientists has revealed the wasp's secret weapon. It makes a virus attack the ladybug's nervous system and brain, so the bug is paralysed and ends up under the wasp's command. In this way, the wasp forces the ladybug to act as a bodyguard protecting the wasp's offspring.

Using its ovipositor, the wasp places a virus-infected egg inside the ladybug's body. When the egg hatches, the virus spreads inside the ladybug, which now considers it its most important job to protect the wasp larva, until it has developed into a fully fledged wasp.

GILLES SAN MARTIN

LADYBUG TURNS INTO WASP BODYGUARD

CLAUS LUNAU

1 **The parasitic wasp** uses its ovipositor to place its virus-infected egg in the ladybug.

2 **The egg** hatches into a wasp larva after about 20 days. The larva appears from the ladybug's abdomen, and an RNA virus known as D. coccinellae Paralysis Virus spreads from the hatched egg to the ladybug's brain and nervous system. The virus attacks the ladybug's brain cells, partly paralysing the insect.

3 **The larva** makes a cocoon between the legs of the ladybug, which remains on top of the cocoon, protecting the larva against predators, as it is converted into a wasp.

4 **A young wasp** appears from inside the cocoon.


Inspiring
AUSTRALIA
An Australian Government Initiative
WHAT WILL YOU BE DOING THIS NATIONAL SCIENCE WEEK?
national science week
15-23 AUGUST 2015
www.scienceweek.net.au
nationalscienceweek
@aus_scienceweek
ABC
abc.net.au
Australian Science Teachers Association
CSIRO
PrimaryConnections
Linking science with literacy
COSMOS
THE SCIENCE OF EVERYTHING
NewScientist
POPULAR SCIENCE

EDITOR: Morten Kjerside Poulsen

Where do fruit flies come from?

I have fruit flies in my home, and I just cannot get rid of them. Where do they lay eggs, and what do they eat?

Fruit flies fly about homes all the time, but they are often so small that we fail to see them. They primarily feed on yeast cells, which they find in stale fruit and the dead leaves of potted plants.

Fruit flies have an excellent sense of smell, so they will soon smell their way to an overripe banana or a semi-rotted orange. Very often, we bring fruit fly eggs back from the supermarket with our fruit and vegetables.

When a female fly has been fertilised, she lays her eggs in soil or in the peel of fruit. The duration of the pupal stage depends on the temperature, and at the high, stable temperatures of modern homes, a new generation of fruit flies will be ready to take off after 8-10 days.

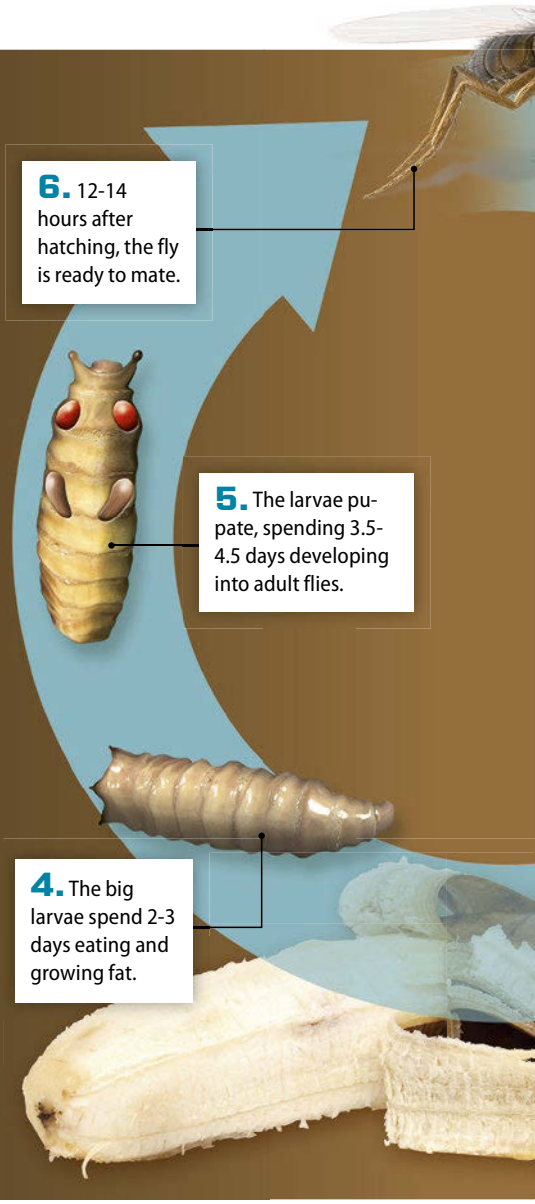
To avoid annoying flies, throw out stale fruit and vegetables and cork up empty wine or beer bottles, which also attract the flies.

GETTY IMAGES

Fruit fly chromosomes

FROM FRUIT FLY TO DNA PROFILES

The fruit fly is an important research animal. Studies of fruit fly genes have laid the foundations of gene manipulation, DNA profiles, and inherited disease research. The fly is a popular research animal, as it reproduces very quickly, does not require much space, and has four large chromosomes, which are easy to study.



IN SHORT

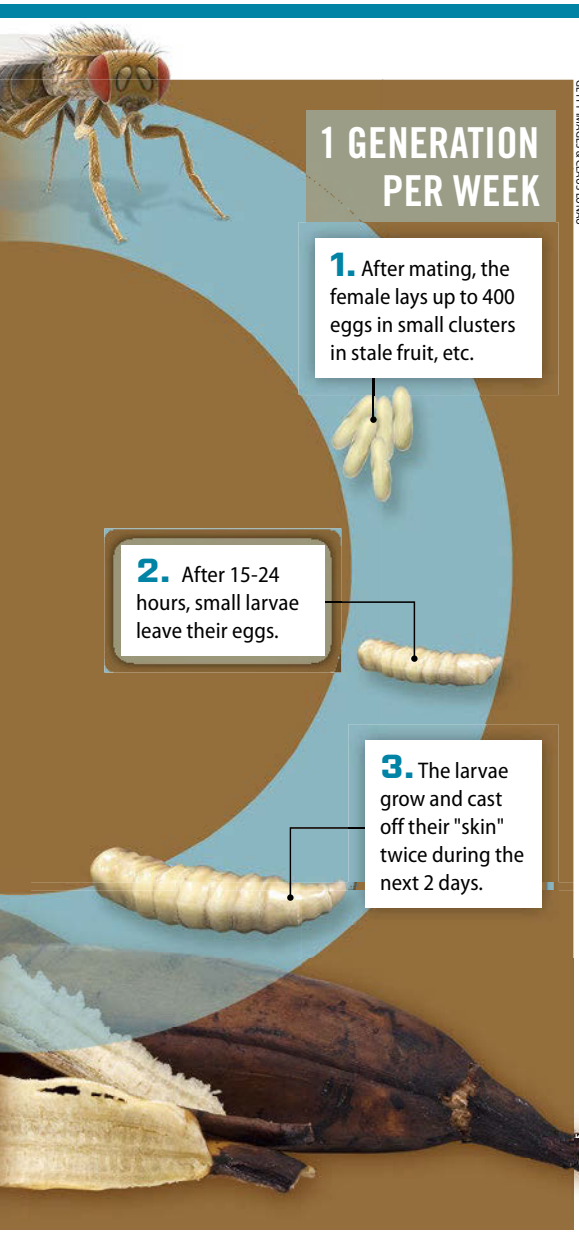
WHY DO WOMEN NOT GROW BEARDS?

Men's hair follicles on the jaw are stimulated by the dihydrotestosterone hormone, which is made of testosterone. Women produce much less testosterone than men, and their hair follicles are less sensitive to the hormone.

What would kitchen scales indicate in space?

Scales that are reset on Earth do not count in the top plate. If you bring reset kitchen scales into space, the weightlessness will result in a negative reading corresponding to the mass of the top plate. If the top plate weighs 8 g on Earth, the scales will indicate -8 g in space. If an astronaut resets the scales in space, the reading back on Earth will be the same, only positive, as Earth's gravitational field pulls the plate against the scales, i.e. +8 g.

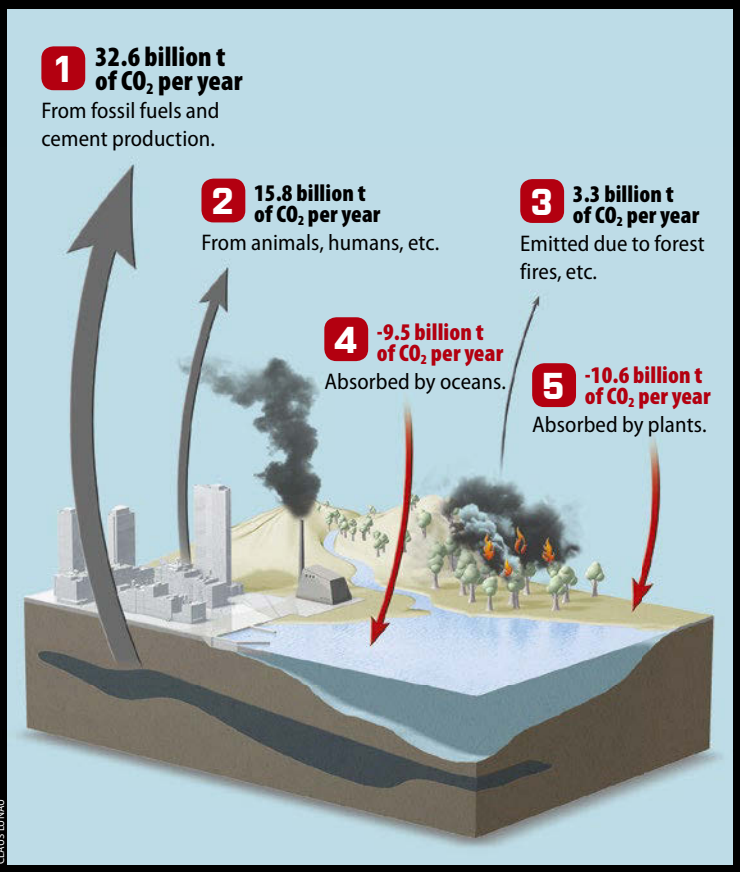
SHUTTERSTOCK



GETTY IMAGES & CLAUS LUNAU

TOP5 WHAT EMITS THE MOST CO2 TO THE AIR?

CO_2 from fossil fuels such as oil and natural gas are not natural ingredients of the atmosphere. So, the CO_2 content of the atmosphere increases, when we extract oil from the ground and burn it. Oceans and plants absorb large amounts of CO_2, contributing negatively to emissions.



CLAUS LUNAU

WERE ALL WITCHES BURNED?

Historically, fire has been a purification symbol, and so, rulers burned people who were assumed to be witches. The first witch stakes appeared before the birth of Christ, and historians estimate that over 50,000 people were executed in Europe in 1400-1750.

75-85 % of the executed people were women, but not all of them were burned. In England, witches were hanged first and subsequently burned in some cases. In other places, victims were decapitated or buried alive. The bodies of hanged witches were often burned, symbolically purifying their souls. Some women drowned during tests to prove that they were witches: If the woman floated, she was a witch and should be burned. If she drowned, she was innocent.

The last official executions took place in Switzerland in 1782 and in Poland in 1793.

WITCHES WERE KILLED BY CARBON MONOXIDE

Some executioners burned several witches at the same time, and it was more often carbon monoxide that killed them instead of burns. Others were killed by the fire: a slow, painful death primarily caused by blood loss and heat. Some executioners could make the killing last more than 2 hours.

SPL/SCANPIX

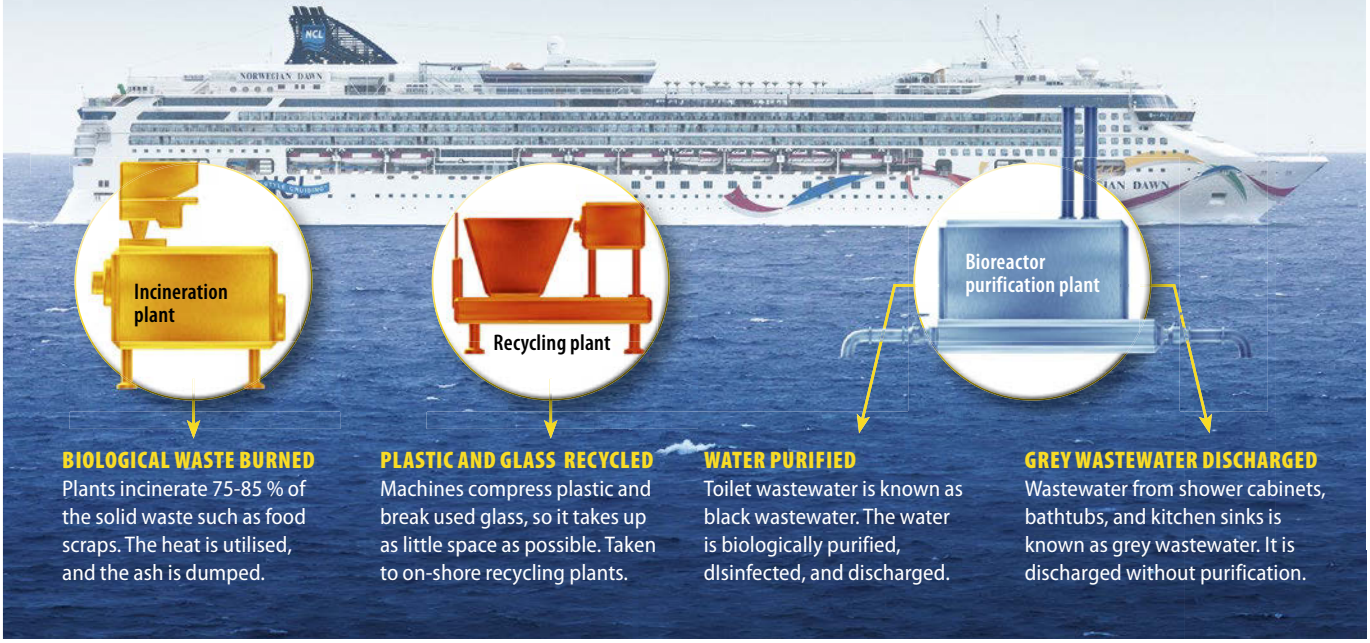
CAN ANIMALS SURVIVE IN SPACE? Generally, animals and humans die in space. But the tiny, sturdy creatures known as tardigrades have survived 10 days in the vacuum of open space.

HOW THINGS WORK

WHAT DO CRUISE SHIPS DO WITH THEIR WASTE?

Some 20 million people annually travel on one of the world's approximately 250 cruise ships. The passengers produce hundreds of tonnes of waste, which is purified and processed on the ship. Some waste is placed in tanks and taken ashore. Other is purified and discharged into the ocean.

FRESHWATER PRODUCED ABOARD
About 1 million litres of freshwater a day – that is how much is consumed on a cruise ship. The vast majority of freshwater is produced aboard by desalinating ocean water and forcing it through membranes to remove salts.



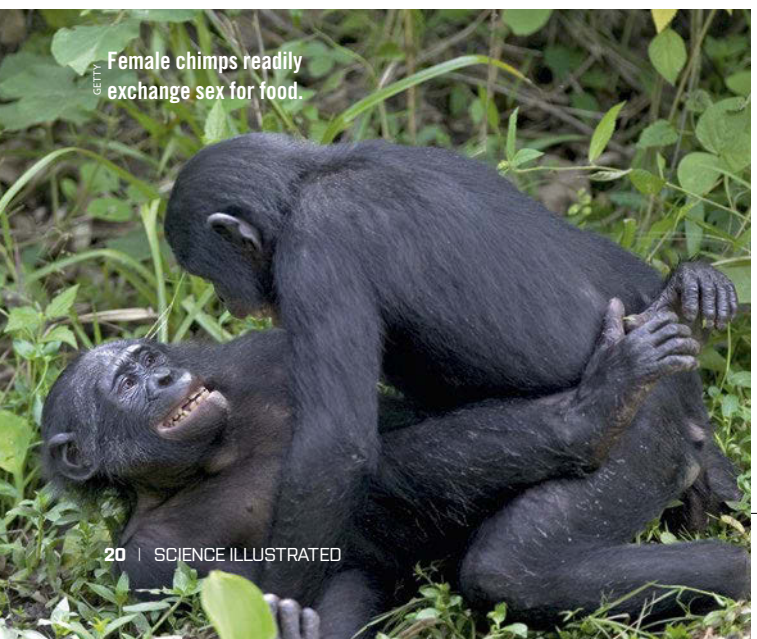
BIOLOGICAL WASTE BURNED
Plants incinerate 75-85 % of the solid waste such as food scraps. The heat is utilised, and the ash is dumped.

PLASTIC AND GLASS RECYCLED
Machines compress plastic and break used glass, so it takes up as little space as possible. Taken to on-shore recycling plants.

WATER PURIFIED
Toilet wastewater is known as black wastewater. The water is biologically purified, dIsinfected, and discharged.

GREY WASTEWATER DISCHARGED
Wastewater from shower cabinets, bathtubs, and kitchen sinks is known as grey wastewater. It is discharged without purification.

SHUTTERSTOCK & CLAUS LUNAU


GETTY
Female chimps readily exchange sex for food.

DOES PROSTITUTION EXIST IN THE ANIMAL KINGDOM?

Among a few animal species, scientists have observed prostitute-like behaviour, as females exchange sex for different services. Animal prostitution was first observed among adelie penguins in the late 1990s. Scientists discovered that some females were willing to have sex with other males but their regular mates, if they were given a stone with which to build a nest in return. Stones are much-coveted among penguins, as there are too few to meet the demand.

A similar phenomenon has been observed among chimps, where females mate with unfamiliar males in return for food. One explanation of the phenomenon is that the males take every opportunity to father more babies, whereas the females test the males' potential.

Why does my voice sound different on video?

When we speak, we hear our own voices as a combination of sound coming from the mouth and sound coming from the jaw and the skull. But on video, only the sound coming from the mouth is recorded, sounding odd to the speaker.

IN SHORT

WHAT CAUSES OUT-OF-BODY EXPERIENCES?

Dying or injured people may have out-of-body experiences, watching their own bodies from the outside. The phenomenon is due to disturbances in the brain region that uses sensory impressions to form body perception.

WHY DOES AIR FEEL FRESH?

Many people experience Scandinavian air as fresh, because it is relatively cool, moist, and clean. This is due to the region's location in the zone of prevailing westerlies on the edge of a continent adjacent to an ocean. Different substances in the air also provide a fresh sensation. Scandinavian air contains so-called terpenes: essential oil produced by pine trees. The terpenes have a fresh smell of pine trees, which is also used in detergents and air fresheners for cars, by which the oil is slowly released inside the cabin.

ALAMY/IMAGESELECT

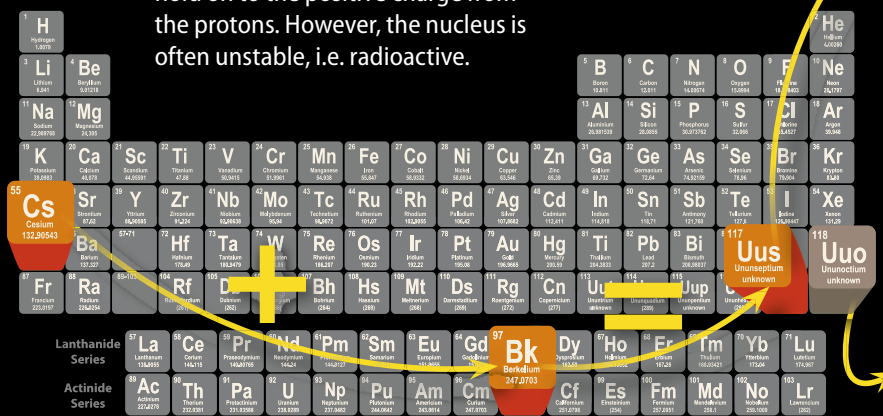
HOW HEAVY CAN ELEMENTS BE?

I heard that new elements can be produced from smaller elements that collide. Is this true, and how large can elements be?

Element No. 117 was discovered in 2014 by colliding the radioactive element No. 97, berkelium, with element No. 55, caesium. The experiment lasted 150 days, and only one in one billion caesium atoms fused with berkelium to become element No. 117, also known as ununseptium. In total, physicists have measured six atoms of the heaviest element so far in the world. Unfortunately, ununseptium decays very quickly into other elements, as it is extremely unstable – like other new, superheavy elements. Physicists disagree as to what is the upper limit. Some believe that the limit is No. 128, others suggest No. 137 or even No. 173.

Physicists search for stable elements

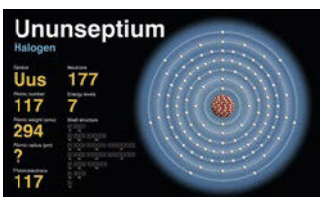
Heavy elements boast many neutrons in their nuclei in order to hold on to the positive charge from the protons. However, the nucleus is often unstable, i.e. radioactive.



SHUTTERSTOCK & SPL/SCANPIX

Ununseptium (Uus)

Ununseptium (Uus) is the most recent superheavy element produced in the lab. It was produced from caesium (Cs) and berkelium (Bk) in a Russian reactor in 2014.



No. 118: Some scientists claim to have produced element No. 118, Uuo, but the discovery has not yet been recognized.

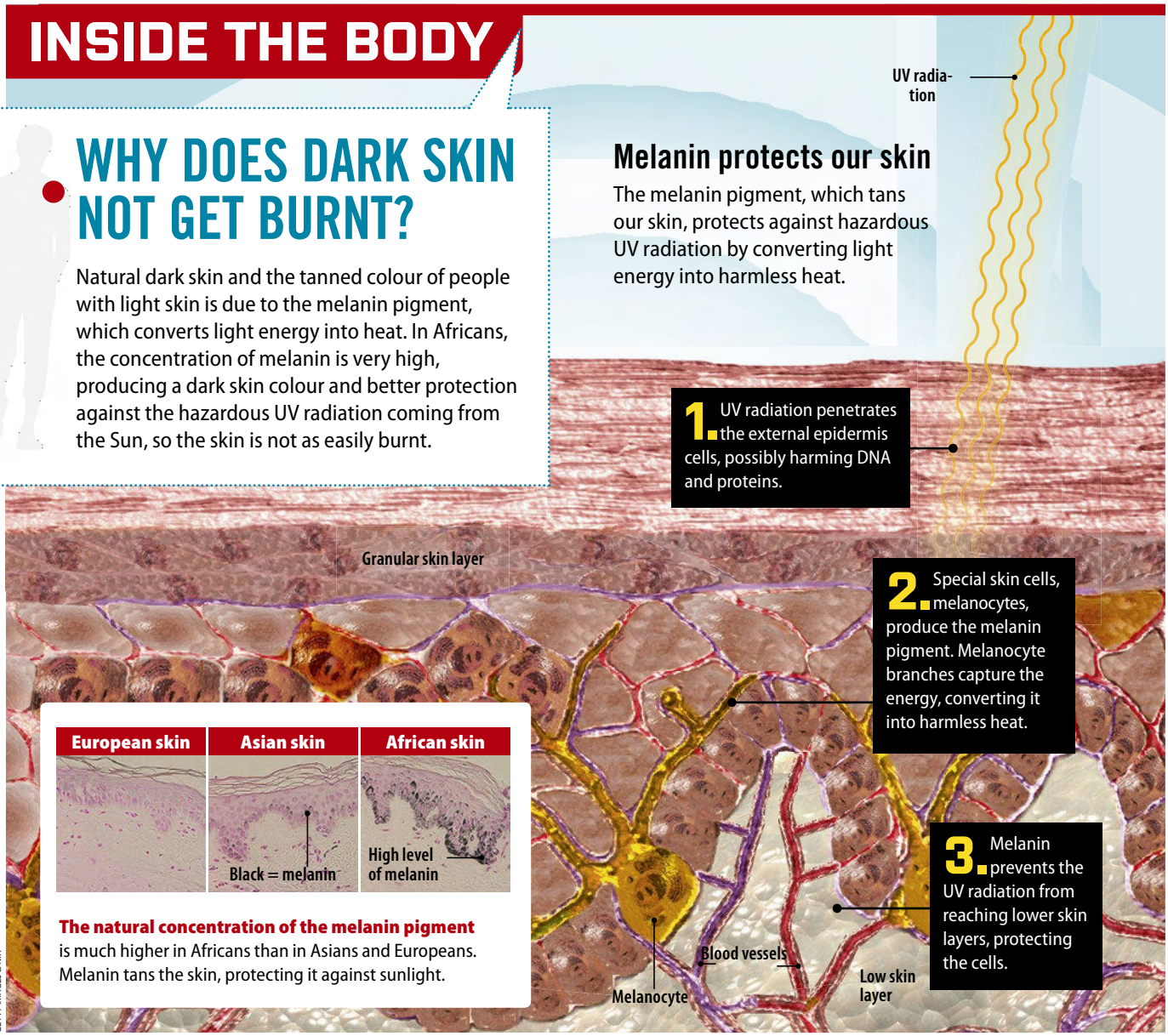
INSIDE THE BODY

WHY DOES DARK SKIN NOT GET BURNT?

Natural dark skin and the tanned colour of people with light skin is due to the melanin pigment, which converts light energy into heat. In Africans, the concentration of melanin is very high, producing a dark skin colour and better protection against the hazardous UV radiation coming from the Sun, so the skin is not as easily burnt.

Melanin protects our skin

The melanin pigment, which tans our skin, protects against hazardous UV radiation by converting light energy into harmless heat.



The natural concentration of the melanin pigment is much higher in Africans than in Asians and Europeans. Melanin tans the skin, protecting it against sunlight.

GETTY IMAGES & NIH

CAN BLACK BOXES FLOAT?

The US Air Force and others have used floating black boxes for several years. Previously, most commercial aviation plane crashes happened over land, and so, floating black boxes did not gain ground on airliners. But in recent years, crashes over open sea have made several companies install floating black boxes on their planes, such as Airbus of France. Also, black boxes are not black, they are orange.

GETTY IMAGES

How much does a cloud weigh?
Its size varies, but the average cumulus – a big, cotton-like, soft cloud – has a volume of 1 km3, contains 0.5 g of water per m3, and weighs → **500 tonnes**

Is it really true ...

... that NASA could broadcast live TV from the lunar landing?

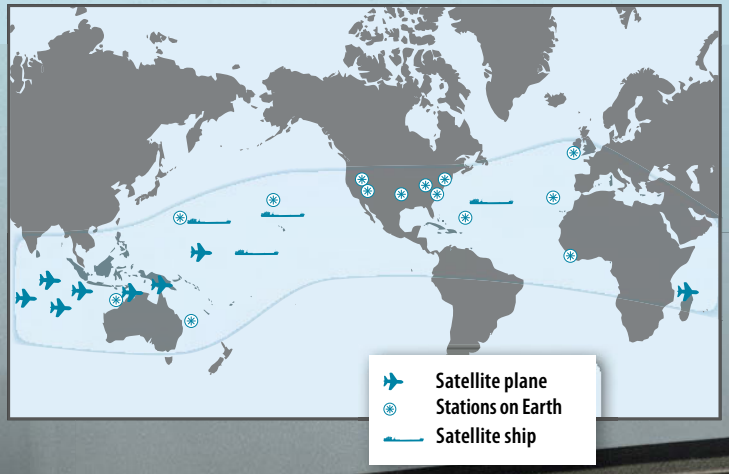
Neil Armstrong's first steps on the Moon were televised. But how could NASA broadcast live TV from the Moon in 1969?

Live TV could easily be broadcast from the Moon in the 1960s, using existing technology. The TV signals were sent via radio waves, which were also used in old-fashioned FM radios. Radio waves are not disturbed, and as they travel at the speed of light, the delay was only a few seconds.

NASA asked two external companies to develop a new TV broadcasting method particularly aimed at the Apollo missions. Sound and video was sent at the same frequency as the other communication between astronauts and Earth. A camera on the outside of the landing module recorded Armstrong's first steps on the Moon. The recordings only involved 10 images/second, so the quality was not as good as the 30 images/second that was the US standard in 1969.

CONTINOUS SIGNAL FOR NASA

NASA established a huge, worldwide network of receiving stations to get a continuous signal from the astronauts in spite of Earth's rotation. The signal from the Moon was received by at least one station and subsequently sent on to the rest of the world.



Approximately 500 million people watched the lunar landing on live TV back in 1969.

SPLASCANPIX & SHUTTERSTOCK

OUR PLACE IN SPACE

For the first time ever, astronomers have mapped out the outskirts of our galaxy. Quite surprisingly, it turns out that the Milky Way belongs to a new giant supercluster, which has been named Laniakea. The supercluster contains no fewer than 100,000 galaxies.

By Torben Simonsen. Art: Mikkel Juul Jensen / scanpix

If Earth had an address, it would be: Earth, the Solar System, the Milky Way, Virgo Cluster, the universe. But that is not correct. Earth's postal code is not Virgo, it is Laniakea.

An international team of scientists headed by astronomer R Brent Tully from the University of Hawaii has tracked the motion of 8,000 galaxies and discovered that the Milky Way belongs to a previously unknown supercluster named Laniakea. The name, which means "immeasurable heaven", makes sense, as Laniakea contains 100,000 galaxies and stretches 522+ million light years, or 260 million times the width of our Solar System.

BYE-BYE OLD SUPERCLUSTER

Planets, stars, and galaxies do not drift about space all on their own, they are ▶

YOUR NEW NEIGHBOURHOOD:

- is 522,000,000 light years wide,
- divided into 100,000 galaxies,
- containing 200 quadrillion stars.

LANIAKEA

VIRGO

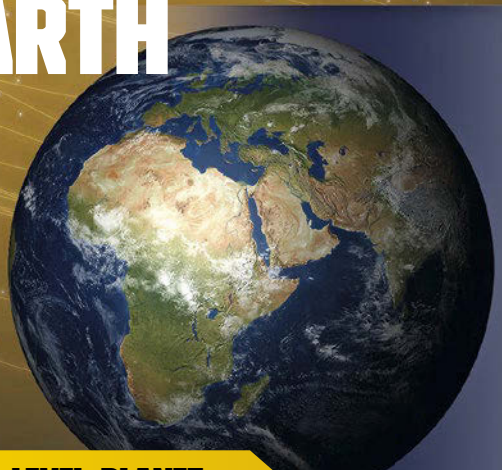
LOCAL GALACTIC GROUP

MILKY WAY

LOCAL BUBBLE

SOLAR SYSTEM

EARTH



SEE HOW SMALL EARTH IS!

SPL/SCANPIX

Earth is a tiny dot in a huge universe

Compared to the vast universe, Earth is a tiny dot. Join us on the 5 sextillion km voyage from our humble planetary home to our new neighbourhood in the giant supercluster of Laniakea.

LEVEL: PLANET

EARTH is a small rocky planet dense enough to exert exactly one gravity on the surface. At 12,700 km, Earth's diameter is only one tenth of Jupiter's – the biggest planet in our Solar System.

▶ part of large structures. Roughly speaking, planets orbit a star, that rotates around a galaxy, which moves in a more complex way through a super-cluster. All these giant structures (superclusters may stretch sextillions of kilometres), are linked to each other by the force of gravity.

For centuries, astronomers believed the Milky Way belonged to a supercluster called Virgo. The cluster includes 2,000 galaxies and stretches 100 million light years, or 50 million times our own Solar System.

But now, the team from Hawaii has analysed the gravity of thousands of galaxies in the neighbourhood of the Milky Way and discovered that the Virgo and several other clusters are only small portions of a previously undescribed supercluster.


IAU

> ***We had not expected that we would find Laniakea. Our analyses brought it to us.***
>
> *R. Brent Tully, astronomer, University of Hawaii, USA.*

Earth orbits the Sun at a speed of 107,000 KM/H

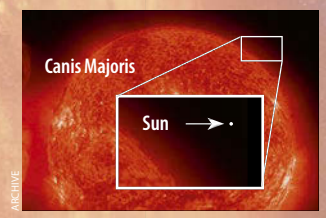
A TEN YEAR PROJECT

The Hawaiian team has been working on the major task of mapping out the outskirts of the Laniakea supercluster for more than 10

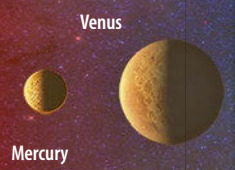
EARTH IS PART OF THE SOLAR SYSTEM

Our Solar System stretches 19 trillion km – or 126,000 times the distance from Earth to the Sun. The centre of the system is its star, the Sun, which has a diameter of almost 1.4 million km. It is the biggest object in our Solar System and accounts for 99.8 % of the total mass.

The biggest star, VY Canis Majoris, has a diameter of over two billion km - almost 1,420 times the Sun's diameter.

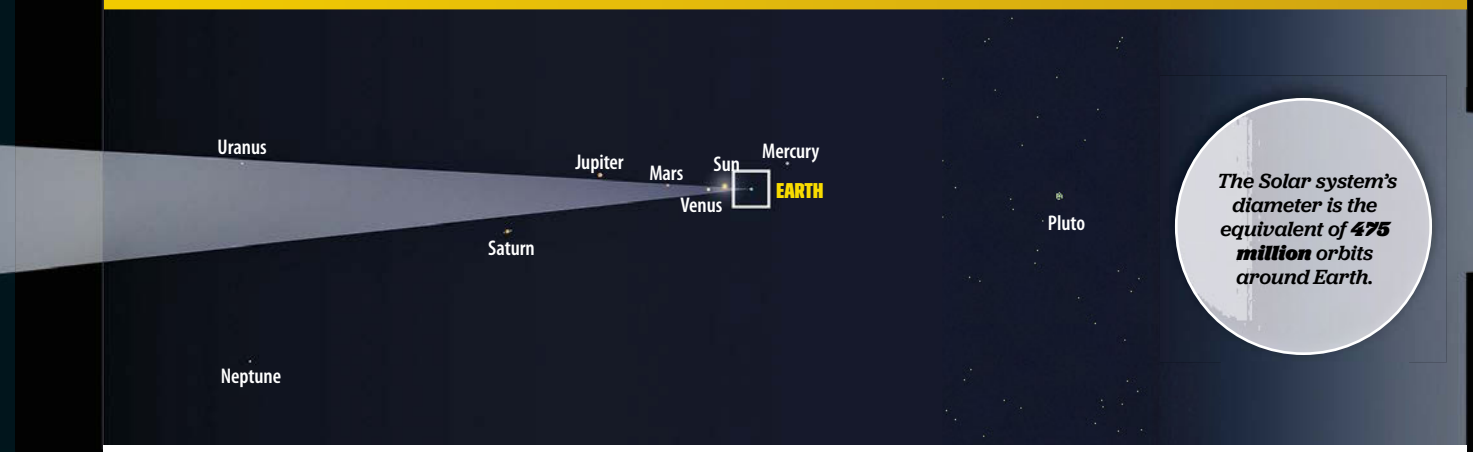


ARCHIVE



Sun

LEVEL: SOLAR SYSTEM

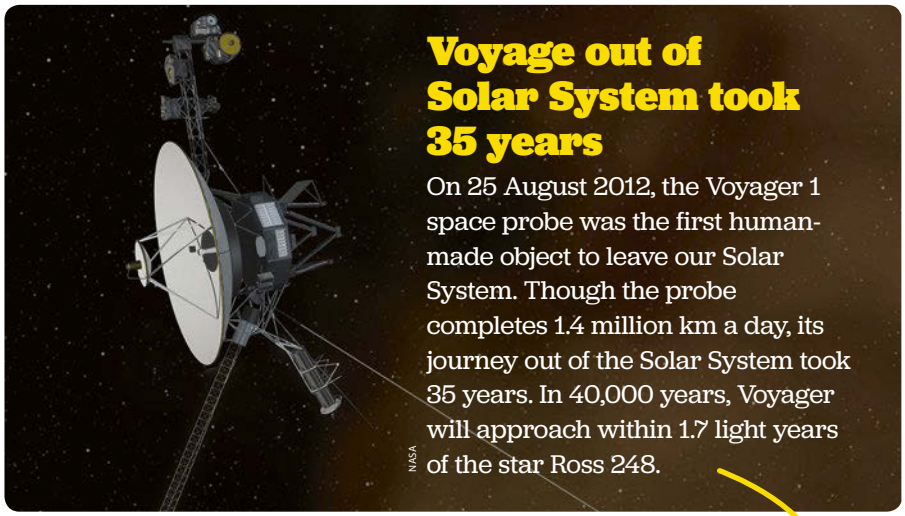


THE SOLAR SYSTEM consists of a star, the Sun, and the objects affected by its gravity. The eight known planets orbit close to the Sun. Further away, you will find the Kuiper belt, which includes dwarf planets such as Pluto, Sedna and Eris; and the Oort cloud.

years. Superclusters have no visible boundaries, but they are defined by the galaxies which orbit the supercluster's centre of gravity.

One orbit around the supercluster's centre of gravity takes millions of years for a galaxy to complete, so astronomers cannot observe to which supercluster a galaxy belongs, they need to analyse their way to its motions instead.

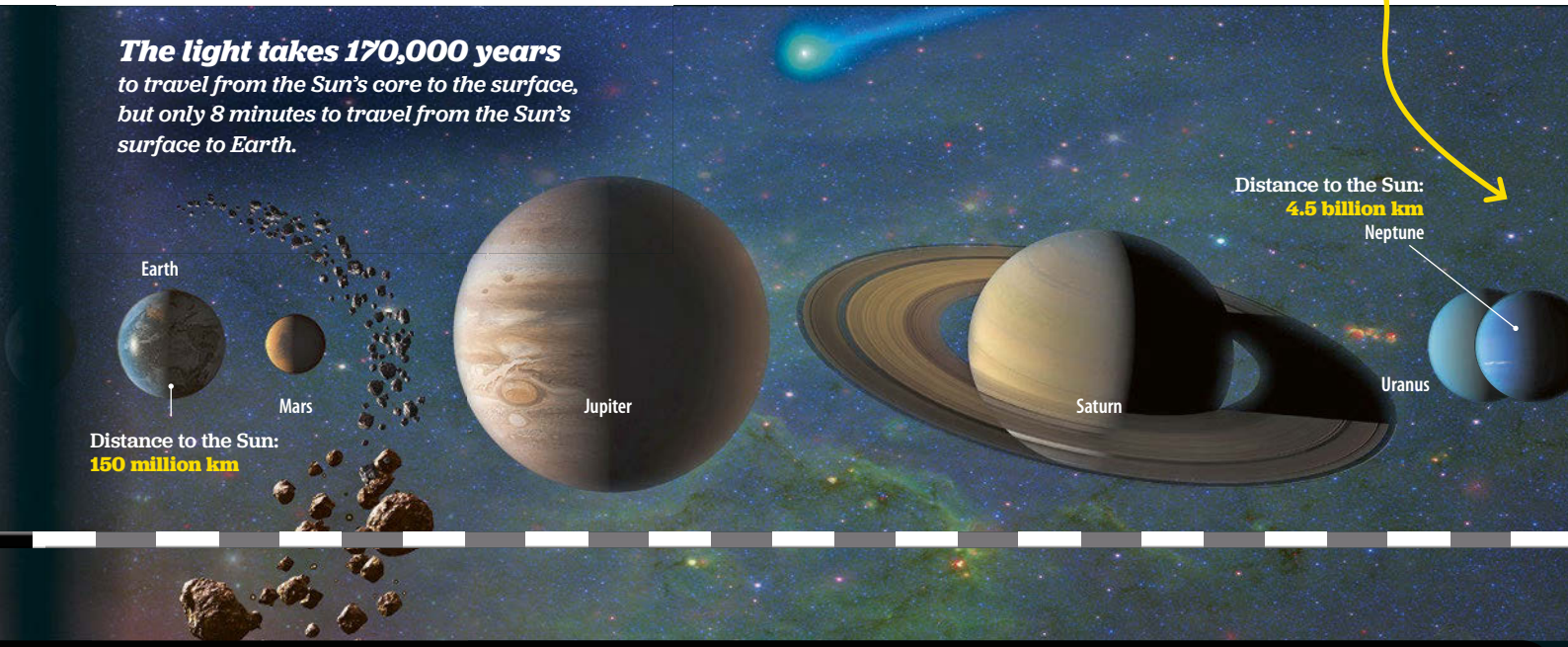
Such analysis requires that scientists know the speed of the galaxies. So, the team collected observations from the optical observatory in Hawaii, the Hubble ▶



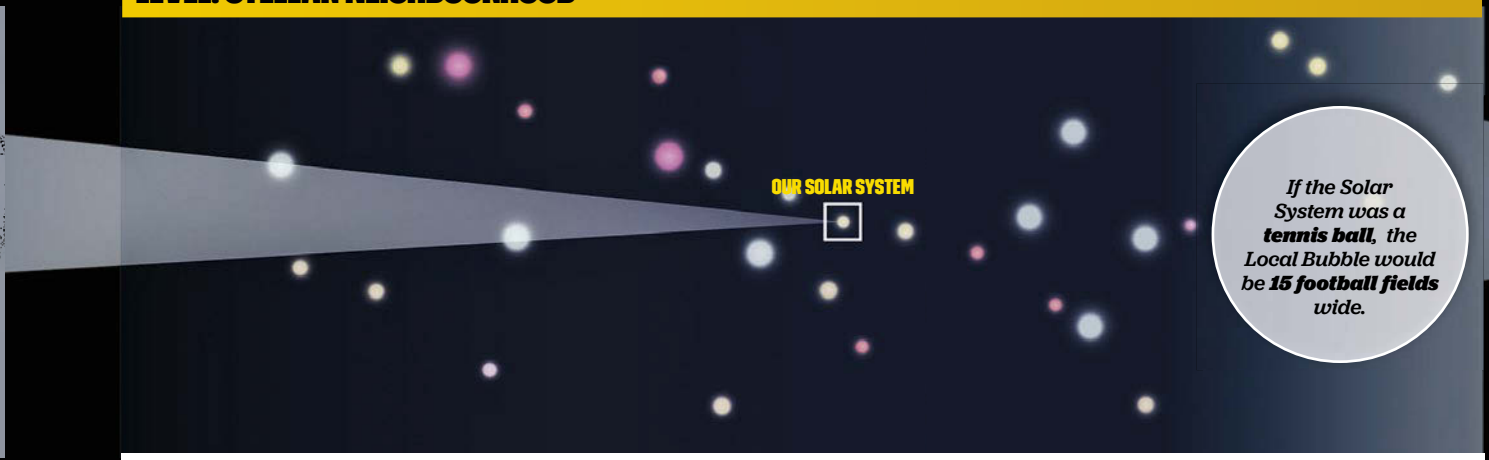
Voyage out of Solar System took 35 years

On 25 August 2012, the Voyager 1 space probe was the first human-made object to leave our Solar System. Though the probe completes 1.4 million km a day, its journey out of the Solar System took 35 years. In 40,000 years, Voyager will approach within 1.7 light years of the star Ross 248.

NASA



LEVEL: STELLAR NEIGHBOURHOOD



THE LOCAL BUBBLE contains the Sun and its closest neighbouring stars. The region is located in a less dense part of the Milky Way's Orion arm and is surrounded by a bubble of warm, ionized hydrogen. Stretching 2.8 quadrillion km, it accommodates 50 stars.

▶ telescope, and a series of other optical radio telescopes. The team obtained observations of 8,000 galaxies and subsequently took a closer look at their light.

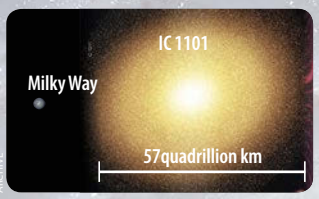
A galaxy's light not only reveals its direction, but also its speed. When a galaxy is moving away from Earth, the light waves are stretched. This makes the light redder and so is known as redshift. The redder, the higher the speed of the galaxy. Light gets bluer and light waves shorter, when a galaxy approaches Earth (called blueshift). Based on the redshift, the team found individual galaxies' speeds and introduced the most extensive and accurate table of galaxy speeds and distances ever made.

GALAXY MARKING

The extensive data enabled the scientists to start visualising the many galaxies' motions using sophisticated 3D models.

"In our Solar System, each planet is surrounded

The biggest galaxy we've spotted, IC 1101, has a diameter of six million light years – over 60 times the diameter of the Milky Way. Containing around 100 trillion stars, it is located in the Abell 2029 galaxy cluster.



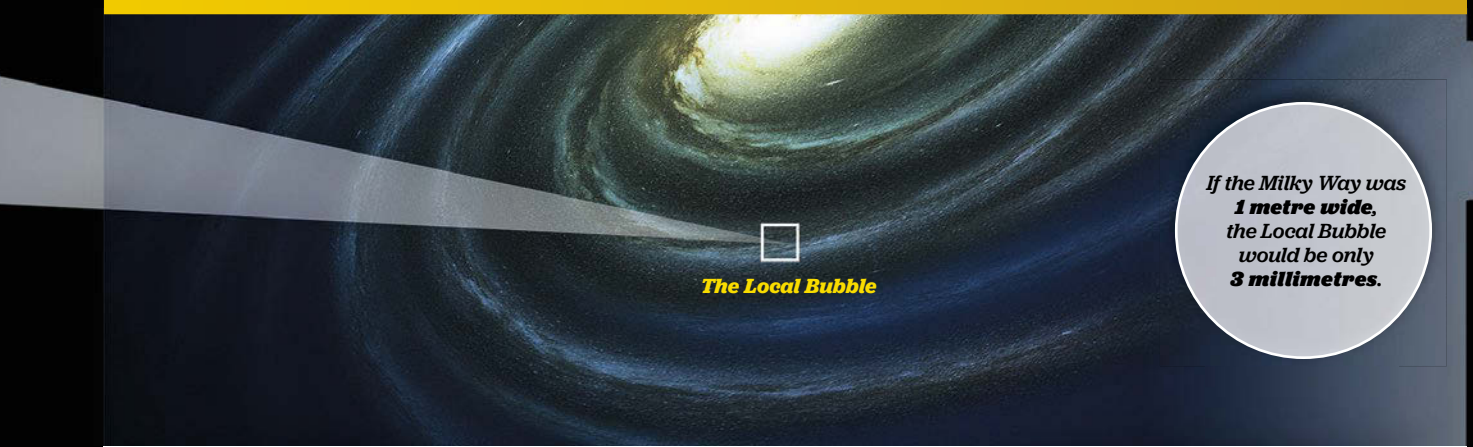
ARCHIVE

OUR SOLAR SYSTEM IS PART OF THE MILKY WAY

Compared to the Milky Way, the Solar System is a tiny dot. Our galaxy has a diameter of 100,000 light years, or 50,000 times the Solar System's, and it is 1,000 light years thick. Distributed between 7 spiral ams, its 200 billion stars orbit a central black hole. Around the stars, even more planets are orbiting, and maybe 10 billion are inhabitable.

The centre of the galaxy is split by a bar. *It is up to 16,000 light years long.*

LEVEL: GALAXY



If the Milky Way was ***1 metre wide,*** *the Local Bubble would be only* ***3 millimetres.***

THE MILKY WAY is a barred spiral galaxy surrounded by spiral arms, where billions of stars and planets are united. They all orbit a central black hole called Sagittarius A*, with a mass four million times the Sun's.

by a sphere, in which its gravity is dominant. Outside the sphere, the Sun's gravity is dominant. At some point, the Sun loses its dominant position, and the galaxy will take over," says R Brent Tully. "We placed a test point on the sphere of each galaxy in order to find out in which direction the galaxies move."

The Solar System rotates at a speed of around

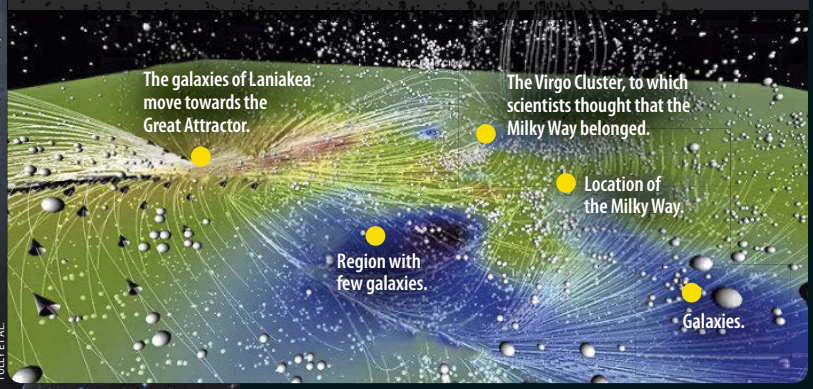
700,000 KM/H

The test points revealed the galaxies' direction of motion and so the centre of gravity around which they rotate.

The boundary between superclusters is found in the place where the galaxies move both in an out. The scenario may seem like a watershed, in which the water may flow in different directions. Very surprisingly, the images revealed a supercluster, whose existence the scientists did not previously know about. ▶

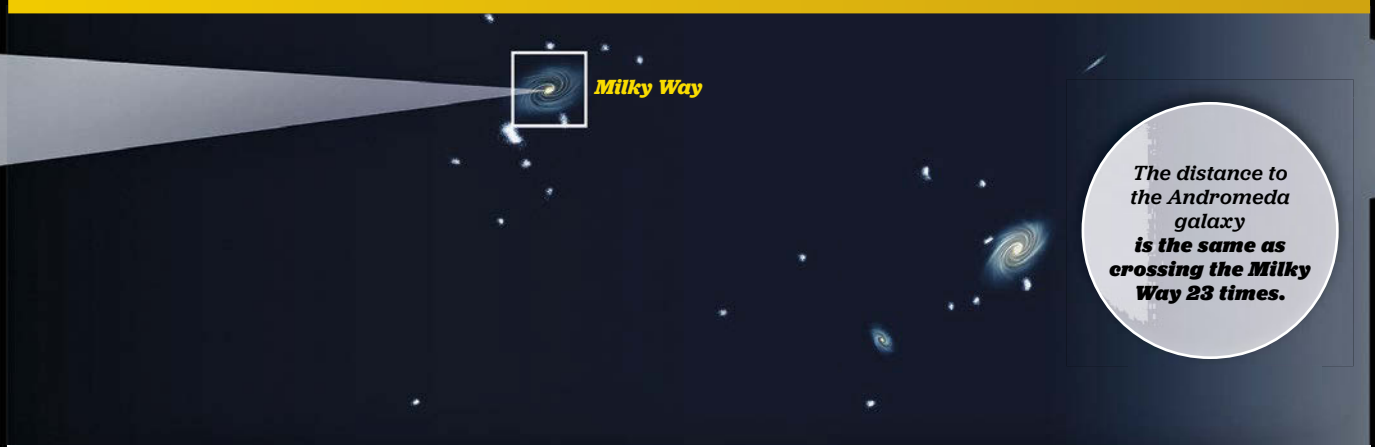
One place draws in Laniakea's galaxies

In the Laniakea supercluster, all galaxies, including the Milky Way, are affected by the same gravity source. The galaxies move towards a common gravity region, which astronomers have named the Great Attractor.



TULLY ET AL.

LEVEL: GALACTIC CLUSTER



THE LOCAL GROUP OF GALAXIES consists of 30-40 galaxies, and its size is up to 100 times the Milky Way's. The galaxies of the Local Group are held together by their mutual gravitational attraction.

▶ "We had not expected that we would find Laniakea. Our analyses brought it to us," R. Brent Tully says.

THE MILKY WAY IS IN THE BORDERLANDS

The mapping of Laniakea supports the model that the gravity that pulls our supercluster together is a field of gravity known as the Great Attractor.

The region is located at the centre of Laniakea and probably has a mass 10,000 times greater than the Milky Way's. The gravity of the region attracts galaxy clusters located several hundred million light years away. One is the Virgo cluster, which includes the Milky Way.

The Virgo Cluster is located on the outskirts of Laniakea and is really closer to the Perseus-Pisces supercluster than to Laniakea. As Perseus-Pisces is one of the biggest superclusters in our part of the universe, it would be natural if the Virgo belonged to it. But the gravity of the Great Attractor is so strong that we instead belong to Laniakea.

The scientists' extensive work is only the beginning. Around Laniakea, there are several superclusters such as the Shapley and the Coma. Their boundaries have not yet been mapped out, but armed with accurate observations, visualisations, and new instruments, scientists will continue the studies in and around Earth's new (and growing) neighbourhood. SCI

the Milky Way moves through space at a speed of

2.3 MILLION KM/H

THE MILKY WAY IS PART OF LANIAKEA

The recently discovered supercluster of Laniakea stretches almost 5 sextillion km and contains 100,000 galaxies with a total of 200 quadrillion stars. All of this is held together by a single centre of gravity, and on the outskirts of this huge structure, you will find Earth.

LEVEL: LARGE GALAXY CLUSTER

Local Group of galaxies

The distance to the closest neighbouring cluster is twice as far as the width of the Local Group.

THE VIRGO CLUSTER includes the Local Group of galaxies and at least 100 other galaxy groups and clusters.

LEVEL: SUPERCLUSTER

*If the Solar System's **diameter was the length of a car**, Laniakea's is **52 million buses**.*

Virgo Cluster

LANIAKEA is a supercluster containing the Virgo Cluster and 300-500 other galaxy clusters around a common centre of gravity.

Address unknown

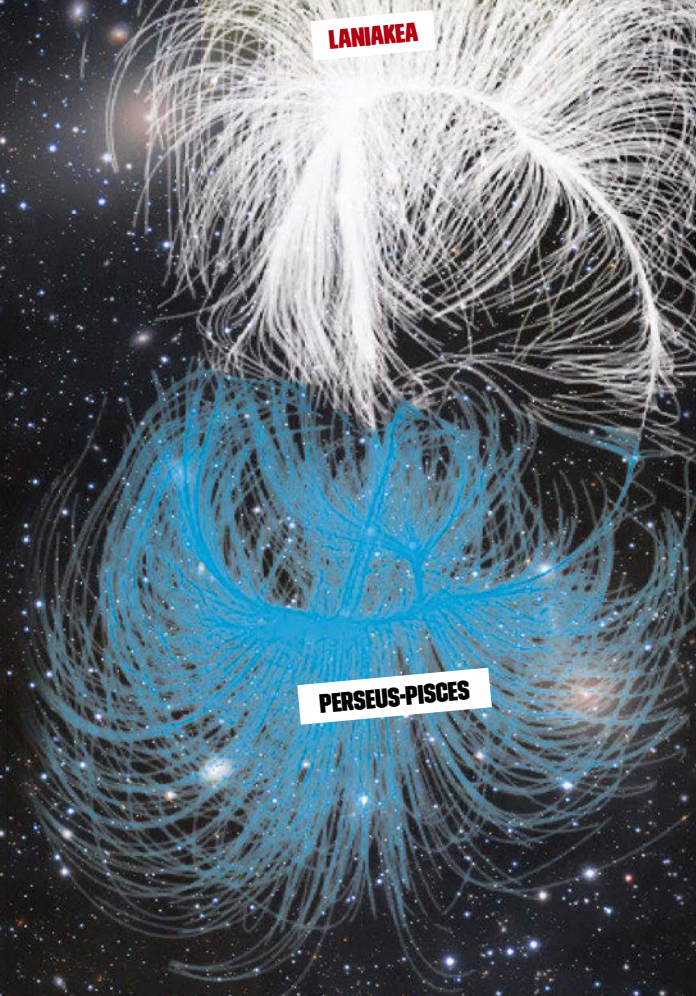
The diameter of the observable universe is a staggering 156 billion light years and contains more than 100 billion galaxies, each home to billions of stars and even more planets. Earth is the centre of our *observable universe*, but our exact location in the universe at large remains a mystery.

NASA

NEIGHBOUR REVEALS LANIAKEA'S PRECISE BORDERS

The boundaries of a supercluster are not visible, but defined by weaker gravity, and it is often difficult to define the size of a supercluster. But close to Laniakea, there is another supercluster called Perseus-Pisces. So, scientists measured the 8,000 galaxies' motions, registering whether they were moving towards Laniakea or Perseus-Pisces. The lines in the illustration represent individual galaxies' motions.

TULLY ET AL.



TYPE: UNIVERSE

THE OBSERVABLE UNIVERSE contains millions of superclusters such as Laniakea.

FALLEN KING

In the new Jurassic World film, the T. REX has been ditched as the lead monster in favour of a genetically modified super-killer. Bit in the real world, the king of predatory dinosaurs is also in steep competition with new discoveries, which reveal that other prehistoric monsters were bigger... and deadlier.

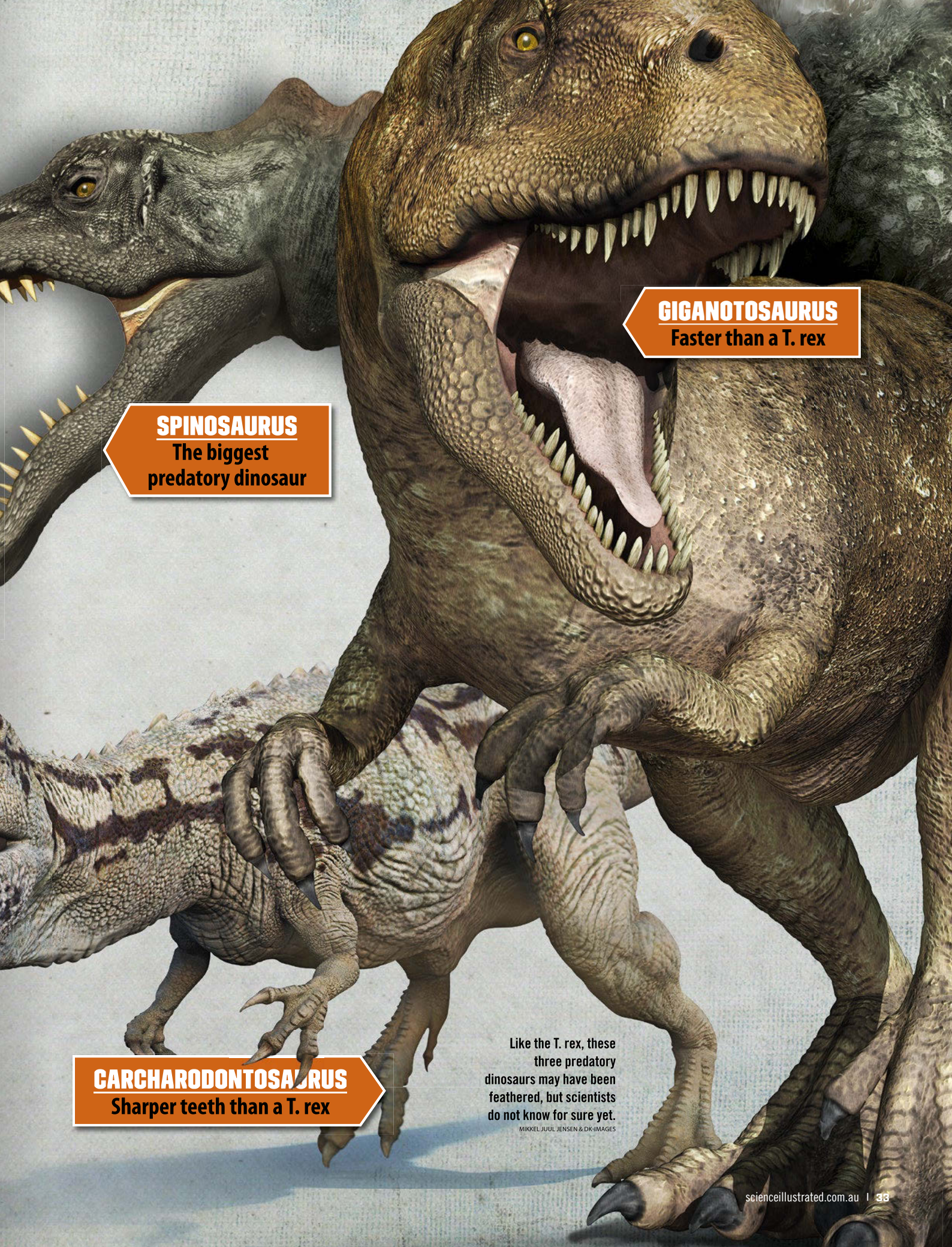
By Antje Gerd Poulsen

T. REX OUTCOMPETED BY GENETICALLY MODIFIED MONSTER

Inspired by the new Jurassic World film, in which a genetically modified monster is created based on the DNA of several dinosaurs, Science Illustrated has carefully chosen the scariest "equipment" from dinosaurs which once roamed the face of the Earth. Step by step, we build our own monster dinosaur with horns, shoulderblade acromions, and tail club.

MIKKEL JUUL JENSEN

It might not look "Hollywood" but it certainly would have been a perfect killer!



Like the T. rex, these three predatory dinosaurs may have been feathered, but scientists do not know for sure yet.

MIKKEL JUUL JENSEN & DK IMAGES

So much for the lawyer. Who can forget the iconic moment in Jurassic Park when he is spotted by T. Rex, cowering on a toilet? Crunch. So goes the first victim. The Tyrannosaurus rex was the unrivalled king of horror, when the first Jurassic Park film opened in 1993. A plastic version of the predator landed in the arms of children throughout the world, who grew up with a total of three Jurassic Park films. Now, the fourth film in the series, Jurassic World, is completing its cinematic run as you read this. But in the new film, the T. rex is outcompeted by a bigger and more dangerous dinosaur, which is created based on genes from different animals and brought up in a lab, just like Frankenstein's monster.

In the real world, the king of dinosaurs should keep one eye on his crown. Since the first Jurassic Park film, palaeontologists have essentially *competed* to find a bigger predatory dinosaur. And new dinosaur fossils have appeared, which are indeed bigger and scarier than the T. rex.

THREE GIANTS

Two new candidates competing to be the biggest predatory dinosaur were discovered back in 1995: the 13-metre Giganotosaurus, whose fossils were found in rock in Argentina, and a Carcharodontosaurus, whose remains were covered by desert sand in North Africa. The two new predatory dinosaurs were almost the same size, and both were bigger than the Tyrannosaurus rex. But in 2014, palaeontologists published a sensational discovery in the desert of Morocco. Bones from the already known Spinosaurus revealed that the four-legged river monster was the biggest predatory dinosaur ever. The Spinosaurus was equipped with a back sail as tall as a man, it could swallow sharks – and it was no less than three metres longer than the T. rex.

The Tyrannosaurus rex was about 12 m long and according to the most recent computer simulations, it weighed 9 tonnes. The length is the safest measure for scientists to determine which dinosaur was the biggest. Weight can be difficult to determine, as different available methods often produce different ▶

8

dinosaurs contribute to our T. rex beating super-dino

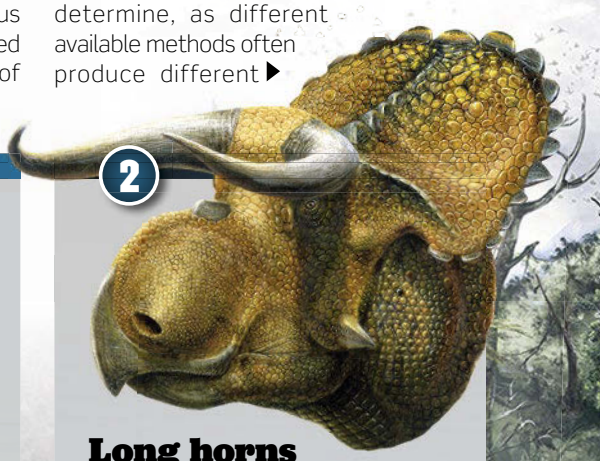
1

The athletic body of a killing machine

GIGANOTOSAURUS: A 13-m-long and 7-m-tall beast of around 8 tonnes, which was not only bigger than a T. rex, it also had stronger arms. Nevertheless, the giant was agile and **able to run at a top speed of 50 km/h** – about 10 km faster than a T. rex.

LEONELLO CANETTI/GETTY IMAGES

2



Long horns hurt rivals

NASUTOCERATOPS TITUSI: The giant horns belonged to a brand new subspecies of horned dinosaurs, which was discovered in Utah in the US in 2006. **The animals interlocked their horns in wrestling games** like deer goring each other.

NHMU/UTAH

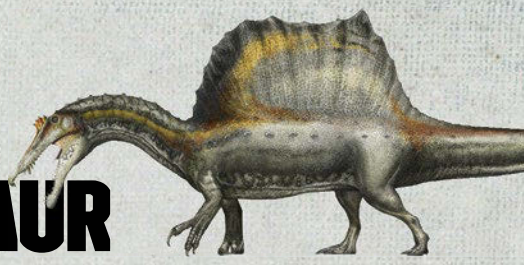
3

Metre-long claws gouge the enemy

THERIZINOSAURUS: Up to 1-m-long claws were characteristic of the Therizinosaurus, which was related to the T. rex and Velociraptor. The odd herbivore had long limbs and was 7 m tall, 10 m long, feathered, lanky, and fat-bellied – and the dinosaur had **3 extremely long claws on its forelegs.** According to some theories, the Therizinosaurus used its terrifying claws in fights with rivals or predators, but the claws were primarily used to cut up tough plants.

STEPHAN LAUTENSCHLAGER/UNIVERSITY OF BRISTOL

RIVER MONSTER IS THE BIGGEST PREDATORY DINOSAUR

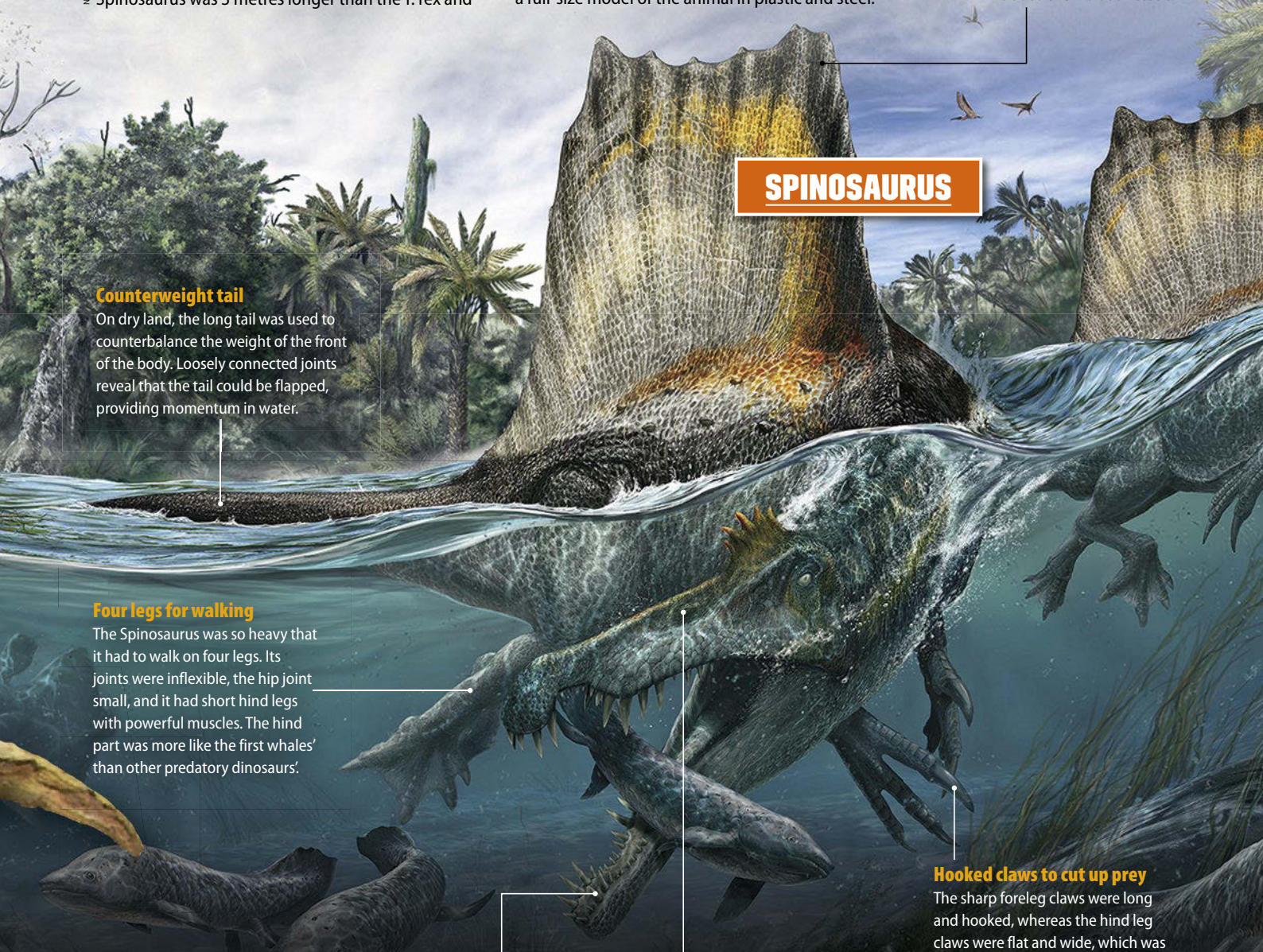


The T. rex is smaller than a four-legged monster with a crocodile beak, which had adapted to life in water.

Ninety-five million years ago, the biggest predatory dinosaur that ever roamed the Earth caused havoc in a major North-African river delta, where it could easily swallow a shark for lunch. The Spinosaurus was the only predatory dino that adapted to life in water, sharing features with crocodiles, water birds, and even whales.

The animal was unlike any other dinosaur with its huge, crocodile-like head and an impressive sail. The Spinosaurus was 3 metres longer than the T. rex and weighed about 7 tonnes. The first Spinosaurus specimen was found more than 100 years ago, but the fossils were lost during a World War II bombing. In 2014, an international team of palaeontologists reconstructed the Spinosaurus based on new bone discoveries made in Morocco in 2008. First, the scientists created a digital version of the predatory dinosaur, and subsequently, they built a full-size model of the animal in plastic and steel.

NGS



Impressive back sail
The big sail was as tall as a man, thin, and probably used to mark the animal's territory. Scientists used to think that the seal was used for temperature regulation, but it was not, as it only included a few blood vessels.

Counterweight tail
On dry land, the long tail was used to counterbalance the weight of the front of the body. Loosely connected joints reveal that the tail could be flapped, providing momentum in water.

Four legs for walking
The Spinosaurus was so heavy that it had to walk on four legs. Its joints were inflexible, the hip joint small, and it had short hind legs with powerful muscles. The hind part was more like the first whales' than other predatory dinosaurs'.

Sixth sense for detecting prey
The snout nerve cells could detect water pressure changes caused by approaching animals. So, the dinosaur could sense prey without seeing it.

Crocodile mouth with razor-sharp teeth
The long, narrow jaws with angled teeth resembled those of crocodiles.

Watertight diver snout
The nostrils, which could be shut, were located in a high position on the snout, allowing the Spinosaurus to breathe with its head partially submerged.

Hooked claws to cut up prey
The sharp foreleg claws were long and hooked, whereas the hind leg claws were flat and wide, which was unusual for a predatory dinosaur. According to scientists, the toes could have been webbed, and the animal may have used them for paddling just like a duck.

SCIENTISTS DREAM OF REVIVING DINOSAURS

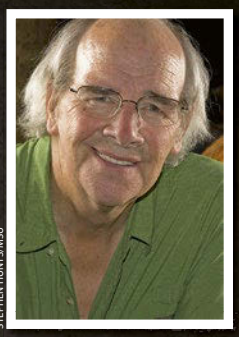
It is virtually impossible to find well-preserved dinosaur DNA. Nevertheless, some scientists believe that it will be possible to recreate dinosaurs in the lab.

The famous "dinosaur baby" was obviously a kangaroo.
YOUTUBE

In 2014, sensational news spread throughout the world via social media: Scientists had recreated a dinosaur just like in the Jurassic Park film. Photos of the dinosaur that had hatched from an ostrich egg aroused great excitement. But any Aussie would have spotted this story as a hoax.

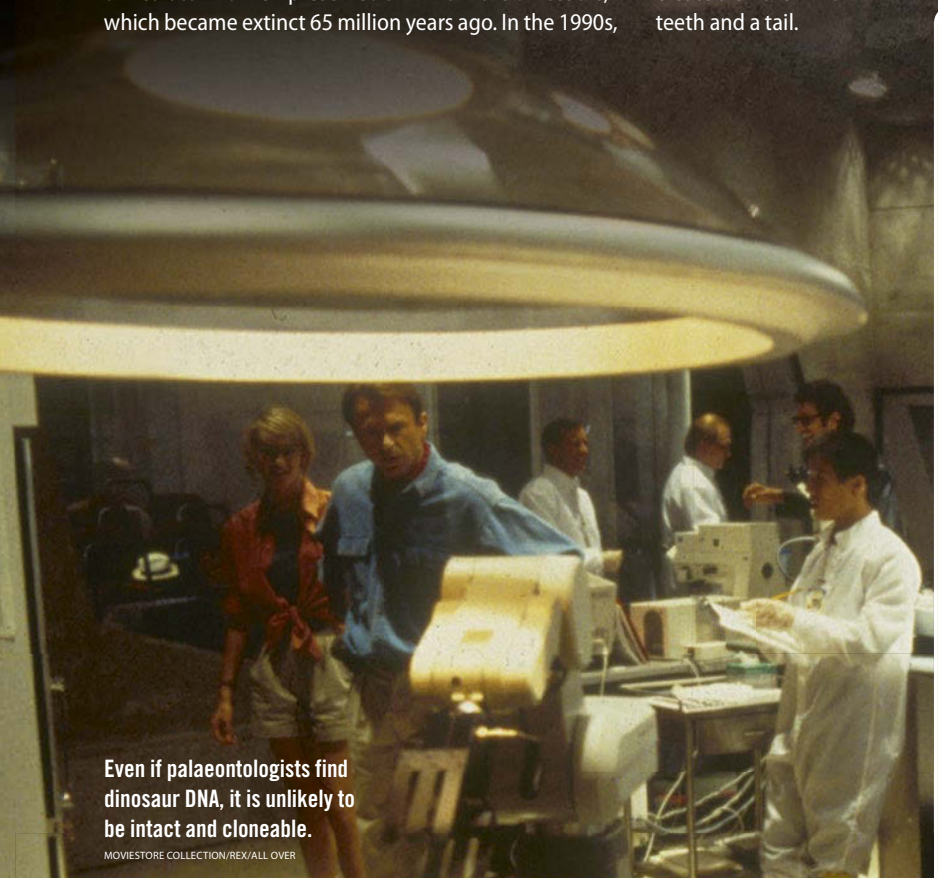
Ever since the first Jurassic Park film, scientists have dreamt of recreating dinosaurs in the lab. Most believe that it will be almost impossible, as DNA is a large molecule, which decays. The oldest DNA ever found is only 700,000 years old and from a horse. So, it will be difficult to find well-preserved DNA from the dinosaurs, which became extinct 65 million years ago. In the 1990s, several scientists claimed that they had found dinosaur DNA in prehistoric insects encapsulated in amber, and in 2013, scientists tried to extract DNA from resin, which is an early version of amber, but in vain. Today, many consequently consider the results from the 1990s to be polluted with DNA from modern animals. Still, some scientists even believe that dinosaur cloning will be possible one day. According to American physicist Michio Kaku, epigenetics and supercomputers can produce dinosaur clones in a not too distant future.

Epigenetics is about activating and deactivating certain genes. All genes of the past still exist in our genetic material, and as birds descend from dinosaurs, they have genes with dinosaur characteristics. A chicken has the gene for teeth, and so, palaeontologist Jack Horner is trying to create a chicken with teeth and a tail.



STEPHEN HUNT/MSU

PALAEONTOLOGIST JACK HORNER served as a technical adviser for the Jurassic Park films. He performs "evolution in reverse", trying to activate dormant genes to provide chickens with the teeth, tails, etc. of their remote ancestors, the dinosaurs.



Even if palaeontologists find dinosaur DNA, it is unlikely to be intact and cloneable.
MOVIESTORE COLLECTION/REX/ALL OVER

RONALD GRANT/AMBLIN/UNIVERSAL/SCANPIX

Ostrich egg

JURASSIC PARK DINOSAURS WERE HATCHED FROM OSTRICH EGGS

■ **In the Jurassic Park film,** scientists clone dinosaurs by means of DNA from mosquitoes encapsulated in amber. The scientists "assemble" the DNA and replace missing DNA sequences with DNA from frogs. Subsequently, they take an ostrich egg and replace the ostrich genetic material with dinosaur DNA. And voila: the scientists created a dinosaur clone.

■ **In Jurassic World,** scientists go one step further, creating a genetically modified monster dino. They replace parts of DNA strands with DNA from other dinosaurs to boost certain qualities.

▶ results. So, the T. rex' weight has differed from 5 to 9 tonnes over the years.

SCARIER HUNTING TECHNIQUE

Like the Spinosaurus, the Giganotosaurus and the Carcharodontosaurus were both bigger than the T. rex, and their hunting techniques were scarier. The two huge predatory dinosaurs were related, but in spite of some similarity, they were not related to the T. rex, but belonged to a group of carnivores known as carcharodontosaurids. The Tyrannosaurus rex and the other tyrannosaurids have big, circular, massive teeth that can crush bones, but carcharodontosaurids have razor- sharp, jagged teeth.

The Gigantosaurus and Carcharodontosaurus attacked bigger herbivores, possibly in groups. Using their teeth, they attacked the animals' legs, necks, and tails, causing blood to flow from big, open wounds. Finally, the victims collapsed and bled to death, as their meat was swallowed by the predatory dinosaurs.

Although the T. rex in the first Jurassic Park film is portrayed as a fast and efficient hunter, the hunting skills of the dinosaur king has later been questioned. According to American palaeontologist Jack Horner, who was involved in the excavation of one of the most complete T. rex skeletons,the predatory dinosaur was much too heavy and slow to hunt, so it was just a scavenger. Like vultures, the T. rex had huge olfactory lobes in its brain and strong leg muscles, enabling it to take long walks, once it smelled dead animals.

But many other palaeontologists disagree with Horner, referring to the fact that like hyenas, the Tyrannosaurus rex was probably both a hunter and a scavenger. In 2013, palaeontologists found sections of a T. rex tooth stuck between 2 tail vertebrae of a herbivorous Hadrosaurus. The bone around the tooth had grown, indicating that the herbivore survived and that the T. rex was not solely a scavenger.

T. REX OUTDISTANCED

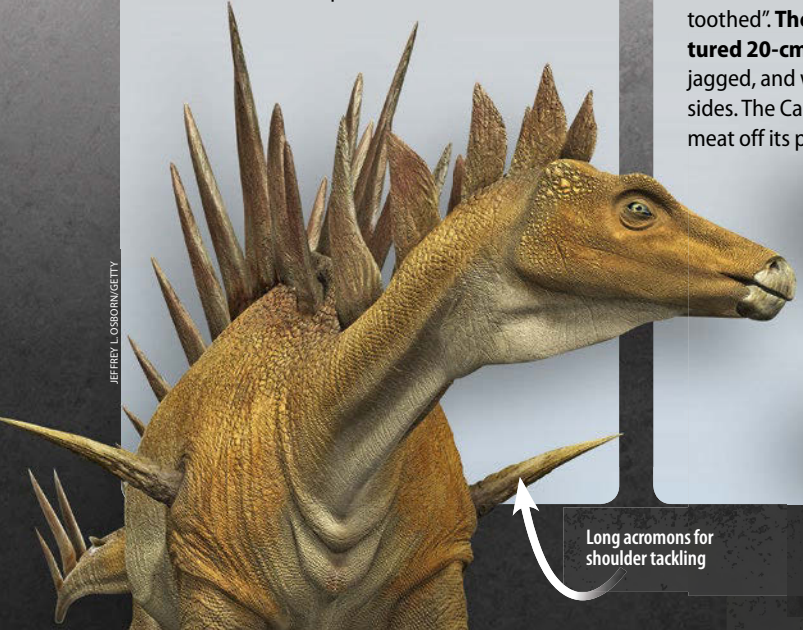
The speed of the dinosaur king has also been challenged by new research. Originally, ▶

The 20-cm-long teeth from the Carcharodontosaurus predatory dinosaur were razor-sharp and jagged.

RYAN M. BOLTON/ALAMY/IMAGESELECT & LOUIE PSIHOYOS/CORBIS/ALL OVER

4 Formidable, 80+-cm-long acromions

TUOJIANGOSAURUS: An efficient defence weapon was a distinctive feature of the Chinese Tuojiangosaurus, which was related to the more famous Stegosaurus: **From each shoulderblade, a 84-cm-long, sharp acromion protruded.** The acromions were placed at about the same height as the chest of attacking predatory dinosaurs such as the 10-m-long and 2-tonnes-heavy Allosaurus, so the 7-m-long and 2-m-tall Tuojiangosaurus was able to come up with a severe tackle.



JEFFREY L. OSBORN/GETTY

Long acromons for shoulder tackling

5 Jagged teeth cut prey to pieces

CARCHARODONTOSAURUS: The T. rex' teeth were massive, almost circular, and best suited for crushing bones and scraping off meat. To get the sharpest teeth, genes must be taken from one of the biggest predatory dinosaurs, which is bigger than a T. rex: the African Carcharodontosaurus carnosaur, whose name means something like "shark toothed". **The animal's mouth featured 20-cm-long teeth** – razor-sharp, jagged, and with incisal edges on both sides. The Carcharodontosaurus ripped the meat off its prey, which bled to death.

Skull

▶ scientists thought that the T. rex, with its powerful thigh muscles and stabilising tail, could move at a speed of up to 50 km/h. But Stanford University scientists have established that the heavy muscles instead slowed it down.

The scientists developed a computer model which can identify animal's running capacity based on motion patterns, weight, and build. The top speed of a Tyrannosaurus rex turned out to be around 40 km/h for young, slim animals, whereas a fully grown T. rex could run at a speed of 15-35 km/h. The agile and fast hunter from the Jurassic Park film was actually heavier and slow... though still plenty fast enough to catch a human on foot. For a real dino-vs-Jeep chase, the films should have used the bigger, but more agile Giganotosaurus, whose top speed was indeed 50 km/h. SCI

FILM FILLED WITH FLAWS

In 1993, Jurassic Park was based on the most recent dinosaur knowledge, but the new Jurassic World is not. These are the three worst flaws, according to an internationally acknowledged palaeontologist, Jesper Milan.

FLAW 1 T. rex and raptors had colourful feathers

FILM: The dinosaurs are smooth, bald, and greyish brown like in the first Jurassic Park films from the 1990's

PALAEONTOLOGIST: All dinosaur groups except the big, long-necked sauropods have been discovered with feathers or a type of hair. Even feathered T. rex relatives have been discovered. But feathers have only been found on animals measuring up to 3-4 m. Perhaps fully grown individuals were indeed bald.


The T. rex was feathered.

FLAW 2 Hands are turned in the wrong direction

FILM: A group of ostrich-like Gallimimuses run with their hands turned forwards, ready to scratch somebody.

PALAEONTOLOGIST: Predatory dinosaur arms fold like in birds. The hands of the Gallimimus and all other predatory dinosaurs in the film – except the T. rex – must point backwards along the forearm, when the animals do not use them. They should not point forwards in a "scratching position" like they do in the film.

FLAW 3 Sea monster is much too big

FILM: A huge sea monster "jumps" out of a pool to capture a big shark, which is used as bait.

PALAEONTOLOGIST: The sea creature is at least twice as big as any known marine animal fossil. In the trailer, you see an animal that is some 50 m long and whose entire body jumps vertically out of the water. That would require a major run-up, which is impossible in shallow water. The animal is not a dinosaur, but probably a mosasaur – a lizard that could grow up to 18 m long. But in the trailer, the sea creature has no split tongue like a mosasaur would.


Mosasaurs are related to lizards, snakes, and monitors.

SERGEY KRASOVSKIY/STOCKTREK IMAGES/GETTY


8 THE TAIL CLUB of the Ankylosaurus beats opponents.

SCANPIX

6 Claws cut prey open

UTAHRAPTOR: The biggest raptor ever found, the Utahraptor, was 7 m long and weighed around a tonne. Apart from being terrifyingly big, the animal had a special "toe claw". **Like a curved knife, the claw rose 23 cm from the foot** – an ingenious weapon used to cut prey in pieces.

JEFF CHASSON/GETTY

7 The most powerful bite

T. REX: The T. rex had one unique characteristic: **the most powerful dinosaur bite of all.** When a T. rex sunk its teeth into prey, each tooth exerted 60,000 newtons, corresponding to the pressure of a fully-grown elephant sitting down on its defenceless prey.

DK-IMAGES

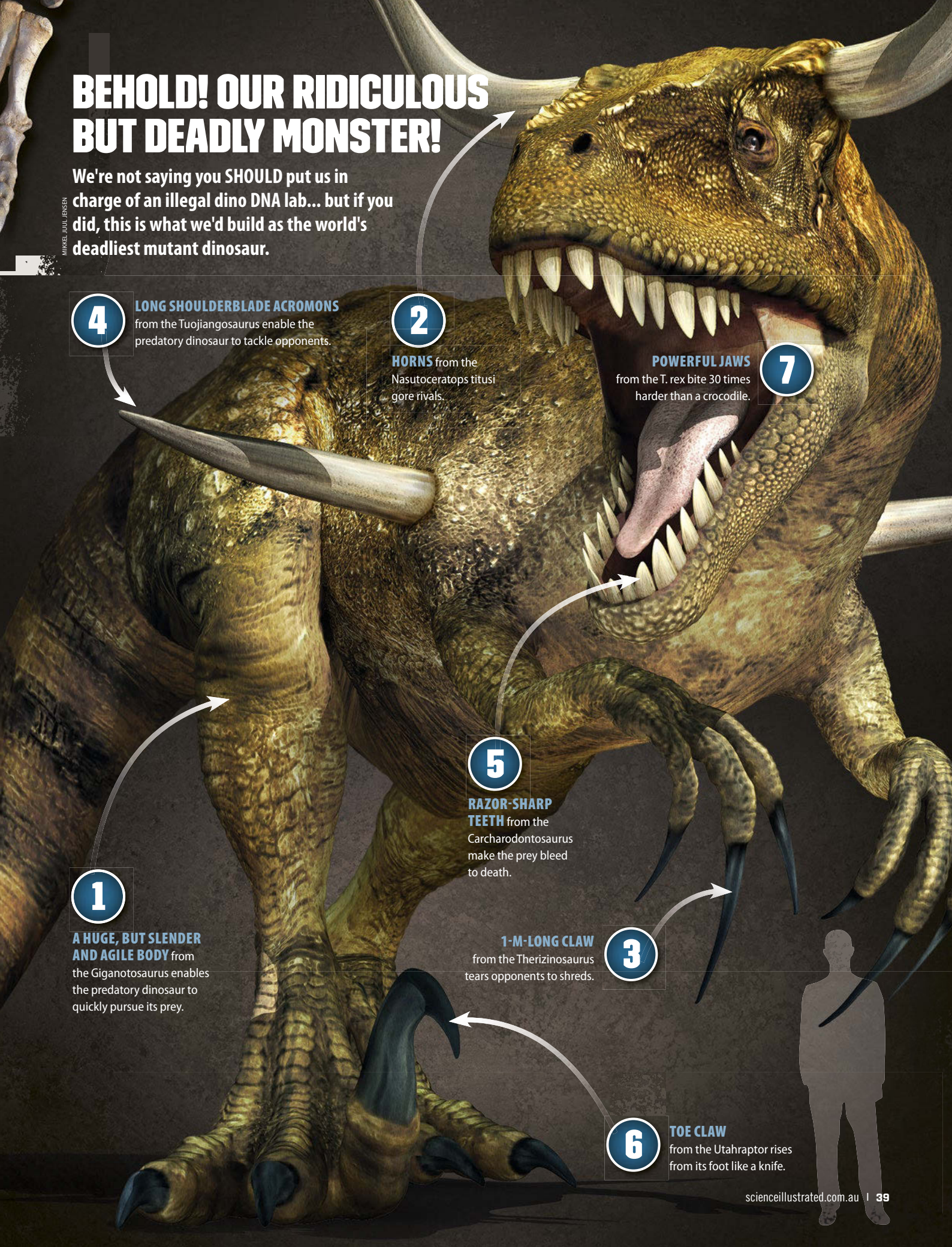
8 Forceful tail club crushes bones

ANKYLOSAURUS: Heavily armoured like a tank and equipped with a tail club, the Ankylosaurus was a difficult mouthful for predators. In 2009, scientists calculated the force of the dinosaur's tail by means of CT scans. They found that the **Ankylosaurus could beat its tail** so forcefully that it crushed bones.

BEHOLD! OUR RIDICULOUS BUT DEADLY MONSTER!

We're not saying you SHOULD put us in charge of an illegal dino DNA lab... but if you did, this is what we'd build as the world's deadliest mutant dinosaur.

MIKKEL JUUL JENSEN



4 LONG SHOULDERBLADE ACROMONS from the Tuojiangosaurus enable the predatory dinosaur to tackle opponents.

2 HORNS from the Nasutoceratops titusi gore rivals.

7 POWERFUL JAWS from the T. rex bite 30 times harder than a crocodile.

5 RAZOR-SHARP TEETH from the Carcharodontosaurus make the prey bleed to death.

1 A HUGE, BUT SLENDER AND AGILE BODY from the Giganotosaurus enables the predatory dinosaur to quickly pursue its prey.

3 1-M-LONG CLAW from the Therizinosaurus tears opponents to shreds.

6 TOE CLAW from the Utahraptor rises from its foot like a knife.

"I'll believe it when I see it!"

... we say. We trust that our senses can distinguish between illusion and reality – particularly our most important sense: vision. But our experience of the world in no way reflects reality as accurately as we think. The brain adjusts and distorts everything we see. And we should be glad, as without the illusions, our vision would not function as efficiently.

By Gorm Palmgren

SHUTTERSTOCK

OPTICAL ILLUSION

The eye illusion known as rotating snakes makes the brain see motion that is not there.

SHUTTERSTOCK

Do you see two faces or a vase?

Normally, the brain has no difficulty distinguishing between an object and its background. Small surfaces with familiar shapes are typically perceived as the foreground, whereas the rest is the background. But when two coloured surfaces are about the same size, the brain can't easily choose, particularly when both can be interpreted to be meaningful figures.

The phenomenon was discovered by Danish psychologist Edgar Rubin and described in his doctoral thesis from 1915. His vase is a well-known optical illusion. If we focus on the red field, we see a vase on a black background. But focus on the black, and the vase becomes the background, and we see two faces. Surprising us the first time, the effect proves that what we see is the brain's interpretation of reality.

SHUTTERSTOCK

HOW YOUR BRAIN LIES TO YOU: ALL THE TIME!

YOUR BRAIN DECEIVES YOU ALL THE TIME!

INVISIBLE GORILLA

We can only focus on one thing at a time, so we will even miss a dude in a gorilla suit, if we are absorbed in something else.

SHUTTERSTOCK

You are watching a video, in which six people are playing basketball. One team wears white T-shirts, the other one wears black T-shirts. Your job is to count the number of passes made by the white team. At some point, a person dressed as a gorilla suddenly enters the court, beating its chest. The gorilla is visible for nine seconds, before leaving the court. Did you see it?

The famous experiment was made by psychologist Daniel Simons from the American Harvard University. Surprisingly, half of the test subjects watching the video were too preoccupied with counting the passes to notice the unusual creature.

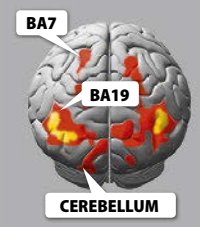
We are used to trusting what we see, but our experience of the outside world rarely reflects reality as accurately as we think. Much of what goes on around us escapes our attention, as clearly demonstrated by the gorilla experiment. And, moreover, we can sometimes be absolutely convinced that we saw something that we did not.

Every second, the retina registers the equivalent of 1 GB of data, but only the most important 0.06 % is passed on to the brain, according to measurements made by neurologist Marcus Raichle. And even this modest amount of data is too much for the brain to deal with, so it will quickly filter out most of it. As a result, only one millionth of all the information that originally met the eye ultimately reaches our conscious minds.

On the way from the eye to our conscious mind, via the centre of vision, a number of pitfalls lurk. The visual impression that we experience is adjusted, misinterpreted, and even manipulated en route. Normally, we do not realise that we have been deceived, but by means of clever visual illusions, scientists can reveal the hoax and learn more about the brain's work methods.

AMBIGUOUS CUBE AFFECTS THE BRAIN

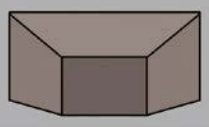
Scans demonstrate that specific brain regions light up when we see inverted perspective.



Region BA7
Maps our position relative to the surroundings.

Region BA19
Part of the centre of vision, visualising depth and shape.

Cerebellum
Coordinates our own motions.



The cube can be seen in two ways.

CLAUS LUNAU

CAMERA REVEALS OPTICAL ILLUSION

For more than 100 years, scientists have used optical illusions such as "Rubin's vase", which is both a vase and two faces, to learn how our brain decodes the world. And using modern technology, they can now reveal exactly how particular optical illusions work, such as the "rotating snakes" (previous page).

The optical illusion exists in several variants, but typically in the shape of

DANIEL SIMONS/HARVARD UNIVERSITY

Test subjects were asked to count the number of passes in this video of a basketball game. 50% missed the gorilla walking through the players.

several circles made up by multi-coloured festoons placed inside each other. The circles seem to be rotating, but they are not.

In 2012, neurologist Susana Martinez-Conde from the Barrow Neurological Institute in the US observed the eyes of a group of test subjects with a sophisticated video camera, as they were watching the rotating snakes. The camera revealed that the optical illusion has to do with microscopic natural motions made by the eyes all the time – so-called microsaccades. As the snakes are made up by sharp contrasts, which attract the eye, our eyes flutter more than they usually do, while we watch them. As a result, the light from one specific detail in the field of vision constantly changes position on the retina, making the brain see motion, although there is none. As soon as the test subjects' eyes "calmed down", the snakes stopped rotating.

Other optical illusions make the brain doubt what it sees. One example is the so-called inverted perspective (see box, left). The simple drawing of a box can be perceived in two ways: seen from the inside or the outside.

In 2007, psychologist Norman Cook from the Japanese Kansai University scanned several people's brains, as they were watching different versions of the illusion, and he identified several brain regions, which are activated when we cannot decide what we see.

Perhaps the brain is in doubt concerning our orientation in the room. One of the activated regions, located at the top of the brain, maps our position as compared to the surroundings. Another one, located in the cerebellum, deals with coordinating our motions.

VERTICAL LINES SEEM SLANTING

One of the centre of vision's most basic jobs is to identify the essential in the field of vision and make it ▶ continued pg. 46

Our vision "edits" reality

Our eyes automatically adjust the contrast between light and shadow to make sure that what we see looks the same under all light conditions. If the contrasts were not corrected, a lawn would appear very differently in sunny and cloudy weather.


SHUTTERSTOCK

CLOUDY
Grass looks like grass
On a cloudy day, the green colour of the lawn is nice and homogenous. That is the picture we get, when we think about a lawn.


SHUTTERSTOCK

SUNNY
Without eye adjustment
The part of the lawn located in the sunlight is intensely green, whereas the part in the shade is almost black. Sharp contrasts.

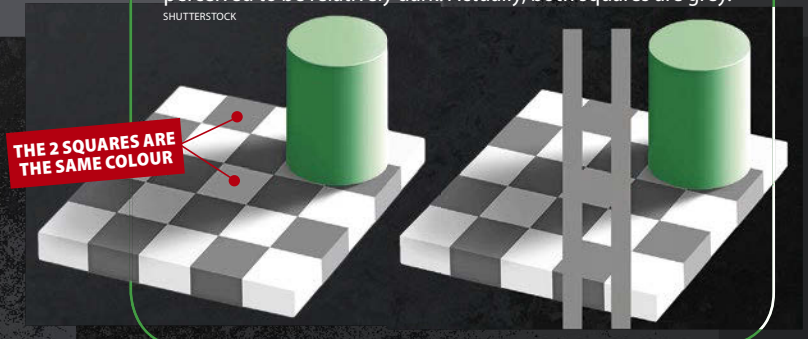

SHUTTERSTOCK

SUNNY
With eye adjustment
The eye makes the lawn look as it always did by brightening the part in the shade and making the part in the sunlight darker.

WE DO NOT SEE THE ILLUSION

Our knowledge about chess boards tells us that one of the two marked squares is black and the other is white. But it is an illusion, as the eye rates colours according to the surroundings. The white square is surrounded by very dark squares in the cylinder shadow and is perceived to be relatively light. The black square is surrounded by very light squares and is perceived to be relatively dark. Actually, both squares are grey.

SHUTTERSTOCK



FRONTAL LOBES:

Logic

The brain accepts the impossible

When the brain has formed a picture of what we see, the frontal lobes consider, if it makes sense. Impossible figures that seem okay at first sight, may make the brain accept the impossible.

JEFF HUANG/GETTY IMAGES

The structure could not exist in reality, as the sides of the triangle connect two different levels.

EYES:

Motions

Eyes constantly flutter

Our eyes constantly make microscopic motions, even if we focus on something specific. The slight motions keep our eyesight sharp, as the retina's light-sensitive cells would weaken, if they saw the same for a few seconds. But it may make us see motion that is not there.

GETTY

Contrasts catch our attention. The fluttering eyes make the brain think that the circle twists.

OPTIC NERVE:

The Blind Spot

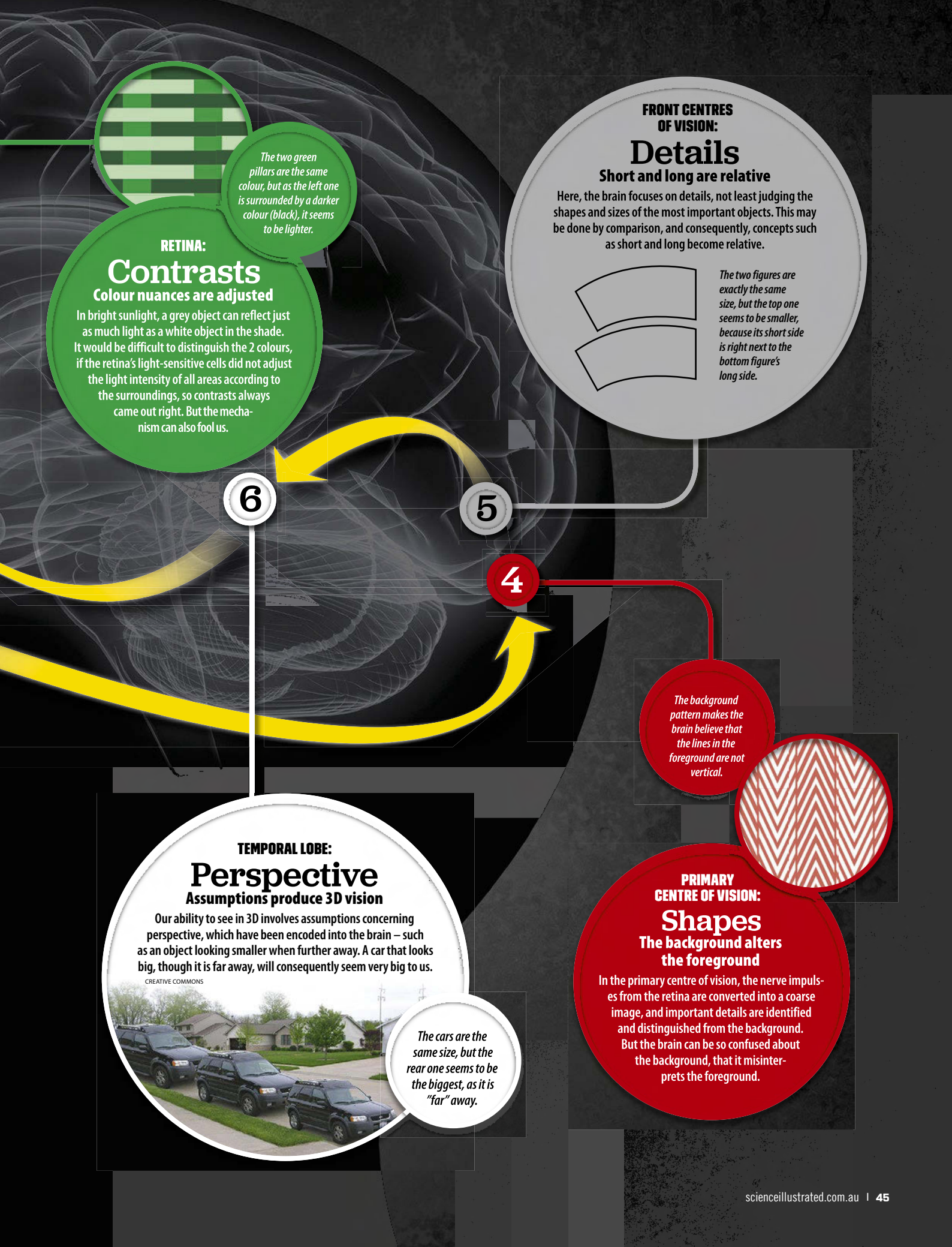
The brain adds information

The optic nerve unites the retina's nerve fibres and transmits the nerve signals to the primary centre of vision at the back of the brain. In the spot where the optic nerve emerges from the retina, we are blind and see nothing. But the brain adds information, avoiding a hole in our field of vision.

7 ILLUSIONS ON THE WAY FROM EYE TO MIND

What we see is the result of a long journey from the eye to the upper cerebral centres. At each level, "data" is interpreted and processed, causing a risk of misinterpretations and optical illusions.

CLAUS LUNAU



RETINA:

Contrasts

Colour nuances are adjusted

In bright sunlight, a grey object can reflect just as much light as a white object in the shade. It would be difficult to distinguish the 2 colours, if the retina's light-sensitive cells did not adjust the light intensity of all areas according to the surroundings, so contrasts always came out right. But the mechanism can also fool us.

The two green pillars are the same colour, but as the left one is surrounded by a darker colour (black), it seems to be lighter.

6

FRONT CENTRES OF VISION:

Details

Short and long are relative

Here, the brain focuses on details, not least judging the shapes and sizes of the most important objects. This may be done by comparison, and consequently, concepts such as short and long become relative.

The two figures are exactly the same size, but the top one seems to be smaller, because its short side is right next to the bottom figure's long side.

5

4

The background pattern makes the brain believe that the lines in the foreground are not vertical.

PRIMARY CENTRE OF VISION:

Shapes

The background alters the foreground

In the primary centre of vision, the nerve impulses from the retina are converted into a coarse image, and important details are identified and distinguished from the background. But the brain can be so confused about the background, that it misinterprets the foreground.

TEMPORAL LOBE:

Perspective

Assumptions produce 3D vision

Our ability to see in 3D involves assumptions concerning perspective, which have been encoded into the brain – such as an object looking smaller when further away. A car that looks big, though it is far away, will consequently seem very big to us.

CREATIVE COMMONS

The cars are the same size, but the rear one seems to be the biggest, as it is "far" away.

SHUTTERSTOCK

Ball trick based on people's expectations

Lots of magic tricks are based on the force of habit. The audience is so used to regular motion that they do not suspect anything, making them easy to fool.

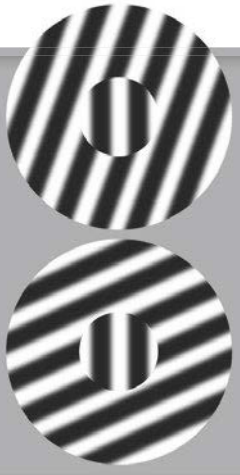
In the "disappearing ball" trick, the magician throws a ball into the air a few times and catches it again. When he finally makes the exact same motions with his hand, eyes, and head, but does not throw the ball, almost all members of the audience will be convinced that they saw the ball fly into the air and magically disappear.

Magician and neurologist Gustav Kuhn from the Durham University in England has performed the trick, as the audience's eye motions were observed by a computer. Most people watched the ball attentively, as it rose into the air the first two times, but the third time, people only looked at the magician's face. According to Kuhn, people were so sure that the ball would just fly into the air again that they chose to look at the slightly more interesting magician instead.

GUSTAV KUHN/DURHAM UNIVERSITY

An experiment has shown what the audience looks at (red circle) in the "disappearing ball" trick. The third time the ball "is thrown", most people look at the magician.

YOUR BRAIN DECEIVES YOU ALL THE TIME!



ISABELLE MARESCHAL, UNIVERSITY OF SYDNEY

BACKGROUND AFFECTS FOREGROUND

In the top circle, the two lines in the foreground seem to lean slightly in the opposite direction of the ones in the background. In the bottom circle, they seem to lean in the same direction. In reality, the two lines are vertical.

continued from pg. 43

stand out from the background. Though the background is often uninteresting, it is an important reference, which helps the brain assess motion, orientation, colour, or contrast in the foreground. However, some optical illusions make the brain so confused about the background that it depicts the foreground incorrectly.

In 2012, psychologist Isabelle Mareschal from the University of Sydney, Australia, introduced a group of test subjects to different versions of an optical illusion involving two vertical lines on a background of slanting lines. The illusion makes it look as if the vertical lines are slanting, but the experiment revealed that the angle of the lines in the background determines in which direction the lines in the foreground seem to lean. If the lines of the background are only slightly slanting, the vertical lines seem to lean in the opposite direction. But if the lines of the background are highly slanting, the vertical lines lean in the same direction. Scientists cannot explain, why the brain makes this interpretation.

We do not notice as many details as we think, so we often do not notice when something changes

DIFFERENT PEOPLE

Optical illusions can make the brain distort reality, be in doubt, or even see something that is not there. But we can also turn blind. Known as blindness to change, the phenomenon is due to us neither being very observant nor good at remembering. We do not notice as many details as we think, and so, we often do not notice, when something has changed. This could be dangerous, such as if we fail to notice a new car on the road, because we were tuning the radio. Even worse, pickpockets use one hand to distract our attention, while removing our wallets with the other.

How extremely inattentive we may be in everyday situations is demonstrated by an experiment made at Harvard. 20 people were asked to participate, and on arrival, they were received by a man behind a counter, who asked them to fill in a form. Subsequently, he ducked behind the counter to find some information for them.

The experiment was really about testing the participant's attention. The man appearing from behind the counter with information was a different person. When scientists later asked the participants, if they had noticed something unusual about the episode, only 25 % mentioned the change.

We are used to trusting what we see, but the next time someone tells us "I saw it with my own two eyes," you will probably be more sceptical. SCI

All senses deceive us

Vision is not the only sense that deceives us. The other senses also alter reality, so we become better at hearing, smelling, etc. – but they can also be deceived themselves.

SHUTTERSTOCK

HEARING The brain finishes sentences

During a conversation in a noisy room, many words and syllables cannot be heard. However, the brain guesses what the other person says, filling in the holes, so we believe that we heard everything.

SMELL We do not notice our own body odour

A new smell activates particular sensory cells in the nose, but if the smell continues to exist, they are weakened and soon stop notifying the brain. So, we usually do not register our own body odour or perfume.

TASTE Old salt stick tastes like a fresh one

Taste experiences are affected by the sense of touch. In an experiment, test subjects held a fresh salt stick in their hands, as they tasted an old, soft salt stick. The old one suddenly tasted fresh, and vice versa.

TOUCH The nose is not a part of the body

Scientists have made people feel that their own noses were located beside them. The scientists took a test subject's hand and made it rub another person's nose, as the person's own nose was touched.

TEST YOURSELF

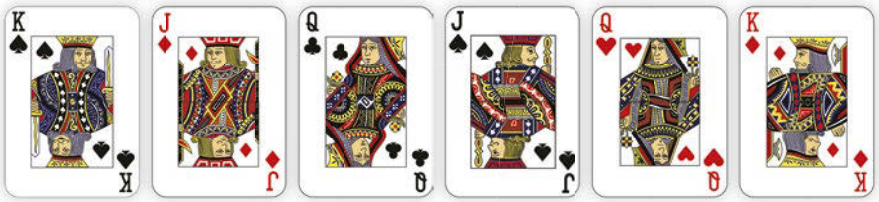
BLINDNESS TO CHANGE We miss changes

We think we see everything that we focus our eyes on, but in reality, the brain registers very little of what the eyes see. So, we often miss something in our field of vision changing, as we briefly look the other way.

PROBLEM

CHOOSE A CARD AND REMEMBER IT

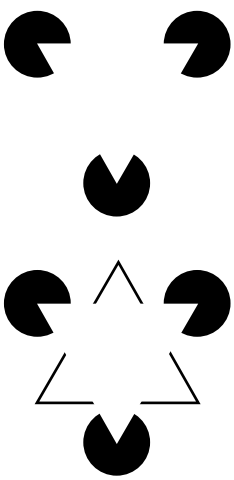
Look carefully at the six cards and choose one of them. Think about the card you chose and remember it. Then look at the cards at the bottom of the page. Is yours among them? Or did it disappear? Look at the cards, before you read the explanation.



LINES The brain draws lines

Our brain instinctively seeks meaning in what we see and automatically looks for the contours of familiar objects. This can make the brain see lines that are not there, whereas some contrasts make real lines slant.

PROBLEM 1



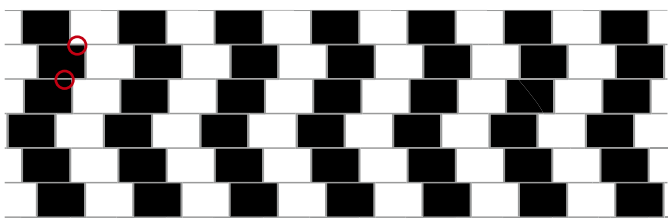
DO YOU SEE A TRIANGLE ATOP THE CIRCLES?

You will probably say yes, and that is remarkable, as there are no lines to indicate it. The brain tends to create lines or contours between points, if it makes sense.
So, it automatically links the angles of the "wedges" to produce a triangle. The effect can be intensified by placing a figure, the angles between the "wedges" in the bottom illustration, on the imagined line, which are provided with a logical purpose, serving as background.

PROBLEM 2

IN WHICH DIRECTION ARE THE LINES LEANING?

Actually, all the lines are parallel, but they seem to be slanting due to the brain's way of processing contrasts. If you look at the top right corner of the individual squares, you will see that some of them have a square of the same colour right above the corner, whereas others have a square of the opposite colour. In the first case, the brain perceives the line to lean right, in the other, to lean left.



SHUTTERSTOCK

ANSWER · THE BRAIN SIMPLIFIES IMAGE

When you saw the 6 playing cards at the top, they included a confusing number of details, so the brain simplified the image, only remembering "picture cards of different colours". That description also fits the 5 cards at the bottom, so most people only notice that their "own" card is gone, though they all are.

LOGIC 2D to 3D translation fails

The brain always tries to understand what it sees, so it becomes easier to relate to. It will quickly decode a specific pattern of lines to be a staircase without paying much attention to details. So, the brain is easy to deceive, when it must translate lines on a flat piece of paper into a 3D figure.

PROBLEM 1

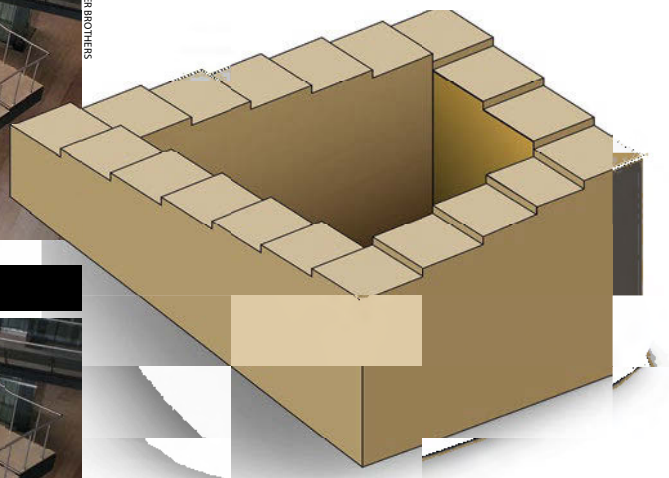
ILLUSION

WARNER BROTHERS

REALITY

WARNER BROTHERS

The Penrose stairs appear in the film "Inception". The stairs cannot exist in 3D, and the bottom image reveals how the illustration was created: The stairs don't meet up in one corner. Only when you see them from one specific angle, the stairs are connected.



SPLSCANPIX

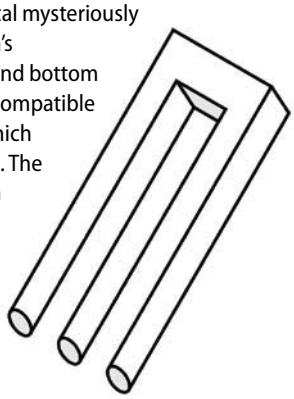
DO THE STAIRS GO UP OR DOWN?

In 1959, mathematician Lionel Penrose and his son drew this odd staircase, which does not begin or end anywhere. Depending on you moving clockwise or counter-clockwise, you will continue down or up indefinitely without ever reaching the bottom or the top. The staircase could never exist in the real world. You can make sure by trying to continue the line from one of the steps all the way round. The line ends up at a totally different level than where it began. So, if you built the staircase in the real world, it would need a gap in one of the corners. Still, at first sight, many people do not notice that something is wrong, as the brain will immediately interpret the lines to be the familiar phenomenon of "a staircase".

PROBLEM 2

DO YOU SEE 3 PILLARS OR A GATEWAY?

The answer depends on whether you focus on the top or bottom part of the illustration, as there is no logical connection between the two. Further down, the empty space at the top of the portal mysteriously turns into a pillar. The brain's interpretations of the top and bottom of the illustration are so incompatible that it cannot figure out which figure we are talking about. The result is a visual impression fluttering between two interpretations. Cover the central part, and the illustration is more pleasant to look at.



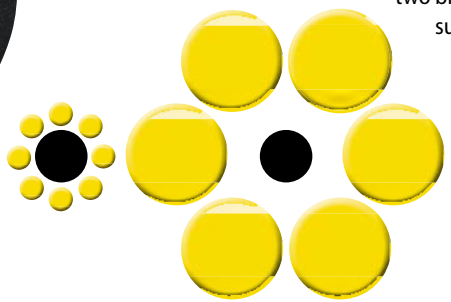
PROPORTIONS The brain determines size in proportion to its surroundings

Our perception of size is highly affected by context. Once the brain has made up its mind, even facts cannot make it revise its opinion.

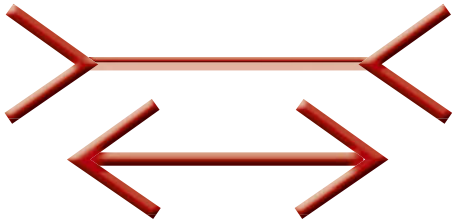
PROBLEM 1

WHICH BLACK CIRCLE APPEARS BIGGER?

Most people would immediately think that the black circle surrounded by small yellow circles is bigger than the one placed among large, yellow circles, but they are the same size. This is due to the fact that big and small are relative concepts, which we rate depending on the context. We think that a bird spider is big, because we compare it to other spiders, whereas a dachshund is small in comparison with an Alsatian. Consequently, the brain is deceived by the fact that the two black circles are surrounded by yellow circles of different sizes. Psychological studies indicate that kids are better at judging the circles, as they think less about what they see than adults do.



PROBLEM 2



WHICH LINE IS LONGER, THE TOP OR THE BOTTOM ONE?

The two lines are the same length, but the arrowheads at the ends make the brain think that the top one is longer than the bottom one. Scientists do not quite agree what causes the illusion, but according to one theory, it is due to the figure produced by the arrows. In connection with the top line, the arrows point in one direction, producing a big, open figure, but in connection with the bottom line, they point in the opposite direction, producing a small, closed figure. The figures are perceived as part of the line.

ATTENTION We cannot focus on everything

Attention is a very limited resource. The brain cannot deliberately focus on several things at a time, and once it focuses on something, almost anything could happen around us without us noticing it.

SHUTTERSTOCK

PROBLEM

WHAT IS THE TOTAL VALUE OF THE CARDS?

You are playing poker and have been delt these cards. If the ace has a value of 14, what is the total value of the cards? Turn the page upside down and see the surprising answer.

ANSWER • YOU WERE DEALT A FAKE CARD

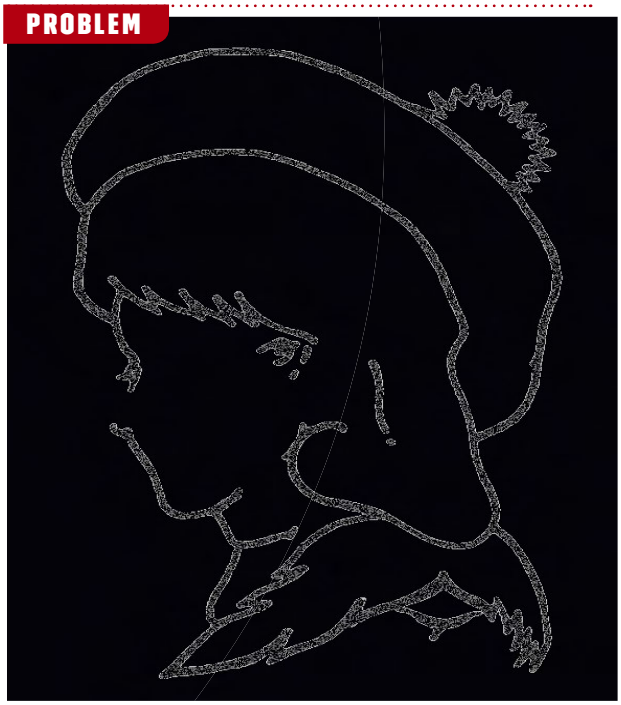
Your answer is probably 28, and in principle, it is correct. But something is still wrong, as you were dealt an invalid card. The vast majority of us will automatically assume that a black card is a spade or a club, like they always are, and when we are busy calculating the total value, we do not notice the 4 is a 4 of BLACK hearts, or an invalid card.

TEST YOURSELF

HIDDEN FIGURES Several options compete

In order to make sense of all the details of the field of vision, the brain focuses on the essential. It is looking for familiar shapes and is particularly attracted by faces. But some illusions involve more than one option, forcing the brain to choose.

PROBLEM



DO YOU SEE THE ENTIRE FAMILY IN THE PORTRAIT?

The brain specialises in recognising faces. At the very moment we identify a line as a nose, we start looking for eyes and mouth. This drawing is a difficult task for the brain, as three different shapes can be interpreted as a nose with eyes and mouth. So, the brain alternately sees the face of a man, a woman, and a young woman, but we cannot see the entire family at the same time. In comparison with Rubin's vase, in which two faces and a vase alternately make up the foreground and the background, the contrast between the figures is less marked in this case. The brain is forced to look for details to focus on – a task that it performs many times every day, such as when we are looking for a person in a crowd.

G.H. FISHER

MOTION Fluttering eyes breathe new life

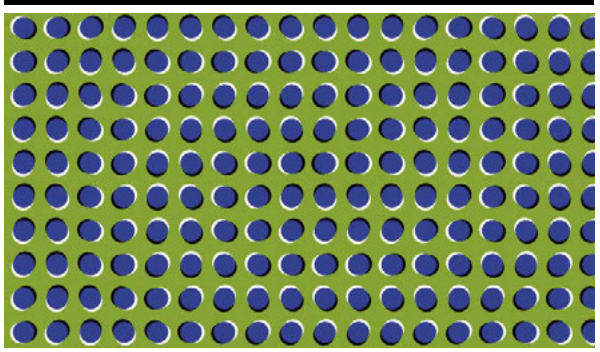
Our eyes constantly flutter to see as much as possible and to focus on motion in the field of vision. The eyes are attracted to contrasts, which is utilised in an illusion making the brain see motion, even though there is none.

PROBLEM

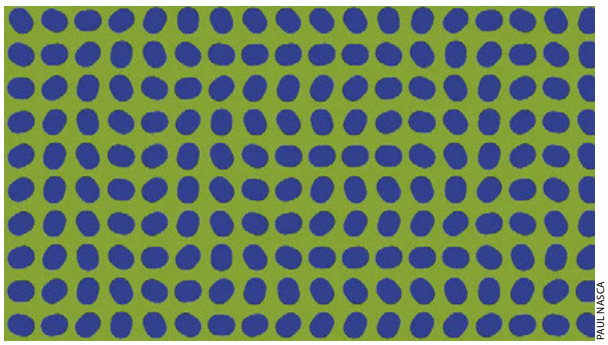
CAN YOU MAKE THE BEANS LIE STILL?

The blue "beans" seem to be constantly moving about. This effect is due to the highlights and dark shades, that the dots have been equipped with at both ends. Our eyes are automatically attracted to contrasts, and as they exist everywhere in the image, the eyes are so busy moving about, that the brain misinterprets the motion and thinks that it is the image which is moving. You can make the beans lie still by carefully focusing on one of them. In the bottom version of the illustration, shades and highlights are gone, and the blue beans suddenly lie still.

THE BEANS ARE MOVING



THE BEANS LIE STILL



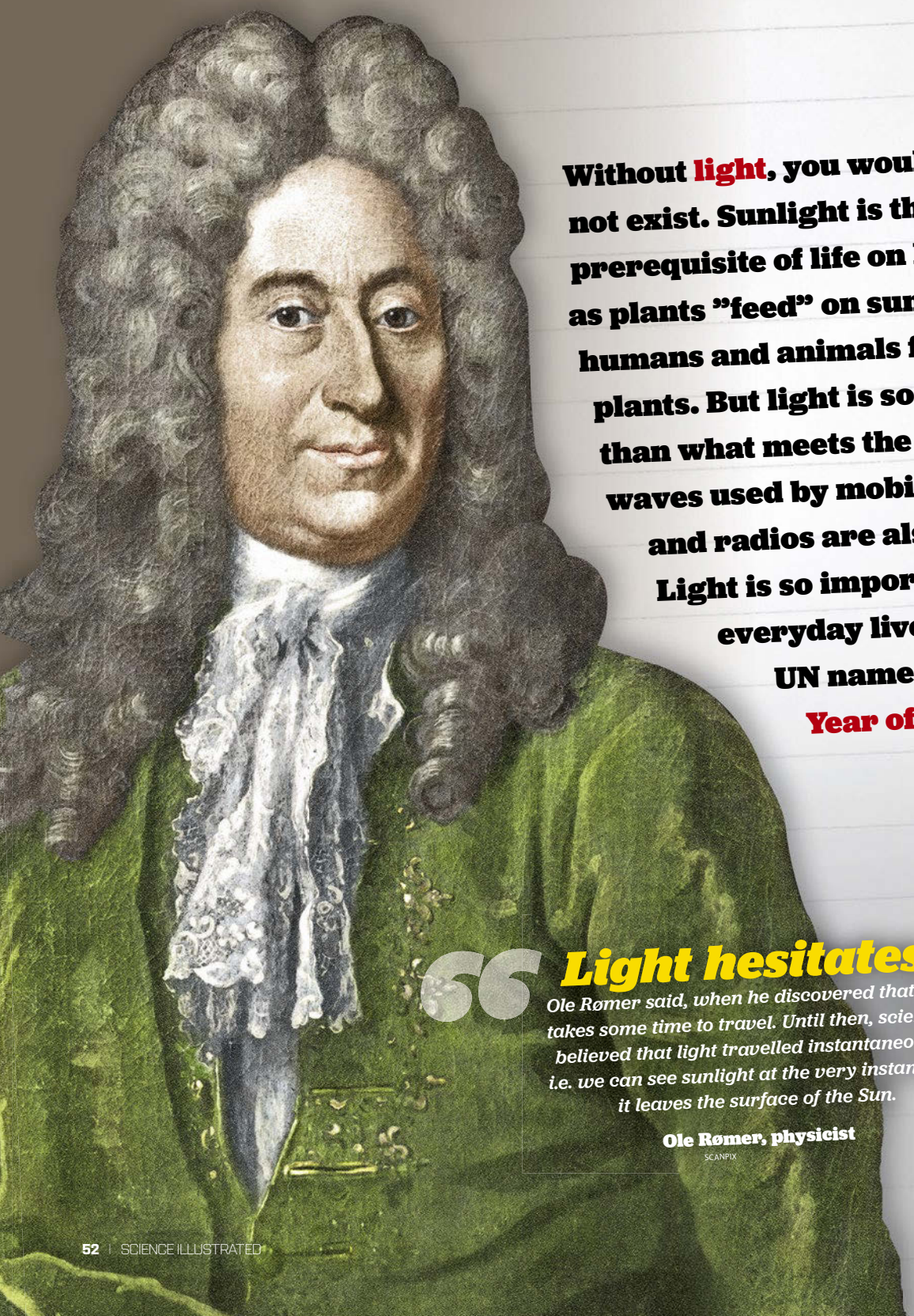
PAUL NASCA

Instant Expert

LIGHT

Spend 10 minutes on our new section and learn more about fundamental physics.

By Rolf Haugaard Nielsen & Malene Breusch Hansen



Without light, you would not exist. Sunlight is the prerequisite of life on Earth, as plants "feed" on sunlight, and humans and animals feed on plants. But light is so much more than what meets the eye. Radio waves used by mobile phones and radios are also light. Light is so important in our everyday lives that the UN named 2015 the Year of Light.

Light hesitates,

Ole Rømer said, when he discovered that light takes some time to travel. Until then, scientists believed that light travelled instantaneously, i.e. we can see sunlight at the very instant that it leaves the surface of the Sun.

Ole Rømer, physicist

SCANPIX

1676

was the year in which DANISH PHYSICIST OLE RØMER proved that light travels at a constant speed. As he observed Jupiter, he could see that the light from the planet reached Earth faster, when Earth was closer to the planet in its orbit and the light travelled across a shorter distance.

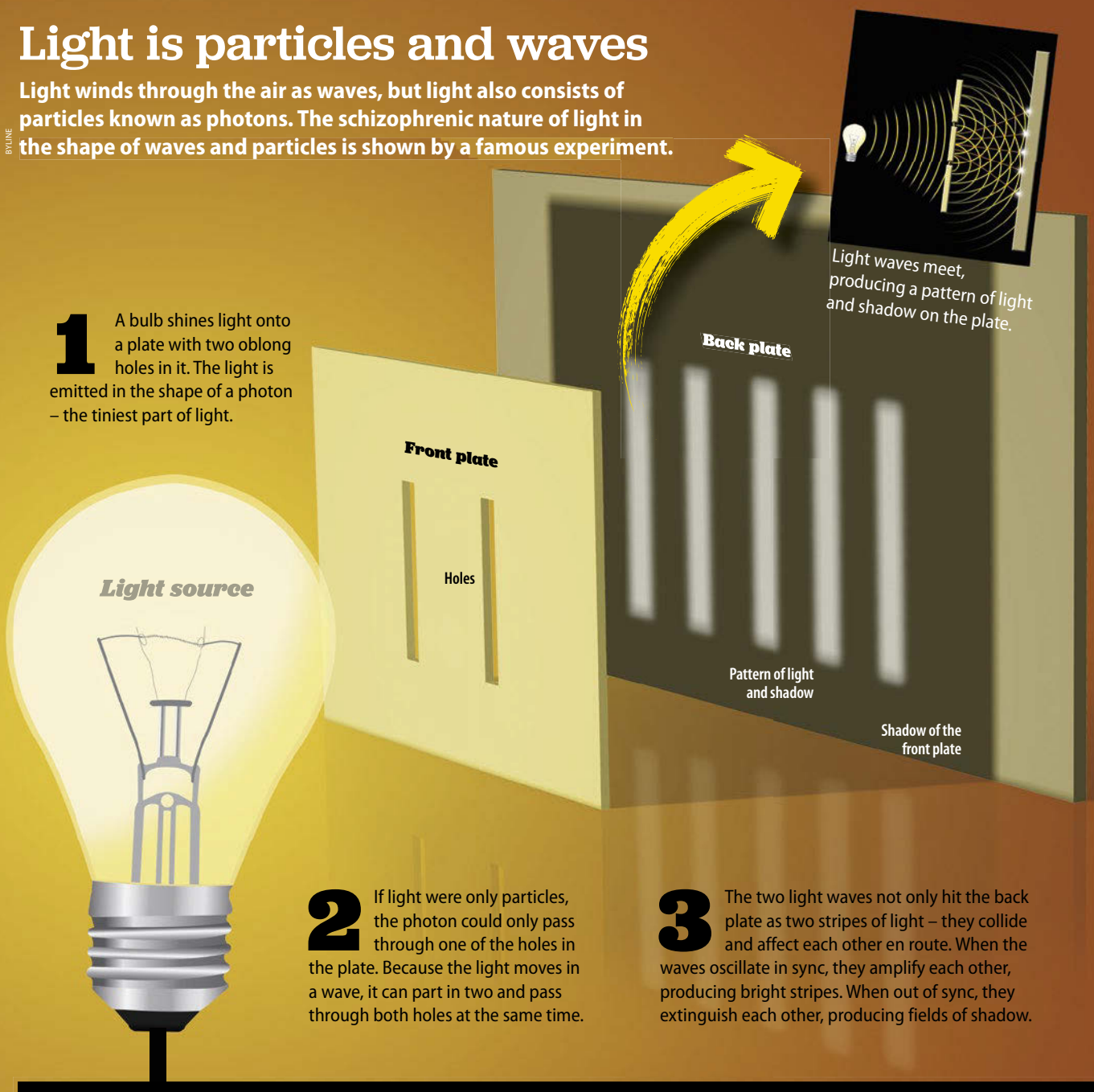
Light travels at a speed of 299,792,458 m/s and its reach is unlimited. Nothing in the universe travels faster than light.

SHUTTERSTOCK

Light is particles and waves

Light winds through the air as waves, but light also consists of particles known as photons. The schizophrenic nature of light in the shape of waves and particles is shown by a famous experiment.

BYLINE



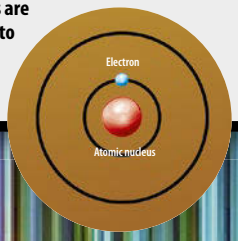
1 A bulb shines light onto a plate with two oblong holes in it. The light is emitted in the shape of a photon – the tiniest part of light.

2 If light were only particles, the photon could only pass through one of the holes in the plate. Because the light moves in a wave, it can part in two and pass through both holes at the same time.

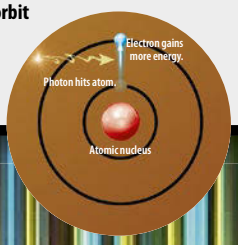
3 The two light waves not only hit the back plate as two stripes of light – they collide and affect each other en route. When the waves oscillate in sync, they amplify each other, producing bright stripes. When out of sync, they extinguish each other, producing fields of shadow.

Light dispatches new light particles

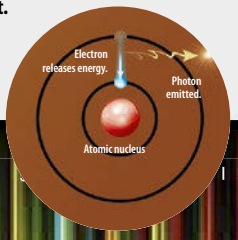
A Light can travel by light particles colliding with atoms, which alter the light and send it on. In an atom, electrons orbit the nucleus. In the material's ordinary state, electrons are low-energy and as close to the nucleus as possible.



B When a photon of particular energy hits the atom, the photon transfers its energy to an electron. This provides the tiny particle with more energy, placing it in an orbit further away from the nucleus – the particle makes a quantum leap.



C The atom cannot exist in its new state for very long, so after the quantum leap, the electron returns to its normal state in the innermost electron orbit. The extra energy is released in the shape of a new photon.



CHALERMLAND/SHUTTERSTOCK

Did you know that

some animals can emit light via from their bodies? Most luminous animals such as jellyfish and crustaceans live in the oceans, but the phenomenon is also known from fireflies. The creatures light up when an enzyme stimulates a chemical reaction between oxygen and a pigment on the animal's surface.

bioluminescense

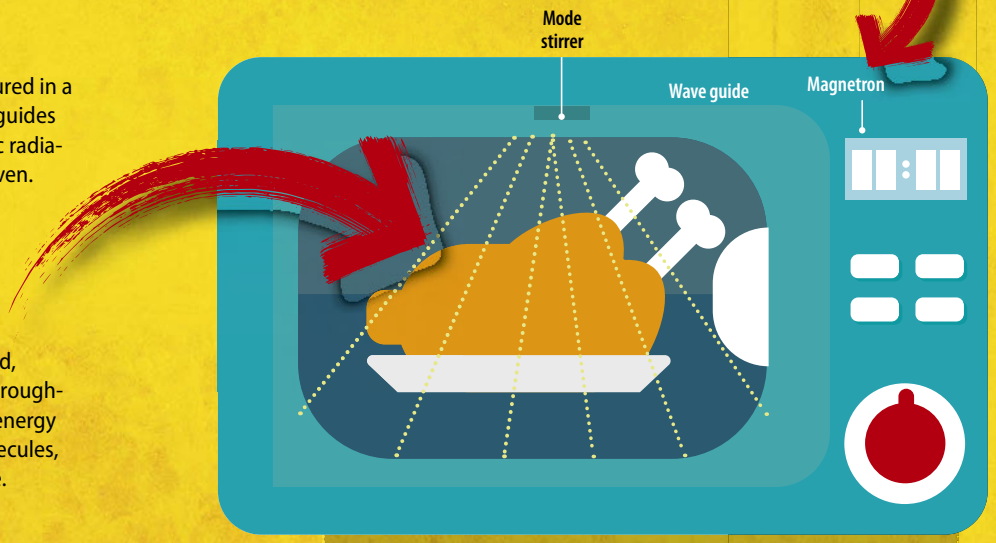
Light is also invisible

The word light is used about the electromagnetic radiation that we can see. But the entire electromagnetic spectrum, from radio waves to gamma radiation is "light" moving in the same way and at the same speed. The invisible waves can see through the human body, carry information through the air, and heat your food very quickly.

1 Microwaves are produced by a magnetron: a vacuum tube with a cathode, that releases electrons. A magnet makes the electrons circulate in the tube, releasing electromagnetic radiation in the shape of microwaves.

2 The waves are captured in a wave guide, which guides the electromagnetic radiation to the entrance of the oven.

3 The waves are spread, dispersing evenly throughout the oven. Their energy is absorbed by the food molecules, making the temperature rise.



Information rides on wave

When you turn on your radio, and music comes out of the speakers, it is possible because of radio waves. A radio transmitter produces a wave of the frequency, at which the communication is to be transmitted. The wave is a so-called carrier wave and contains nothing in itself. But inside the transmitter, video signals or digital data in the shape of radio waves of a lower frequency can be attached to the carrier wave. Upon arrival to the radio receiver, the wave's information is read and turned into what you hear on the radio or watch on the TV set.

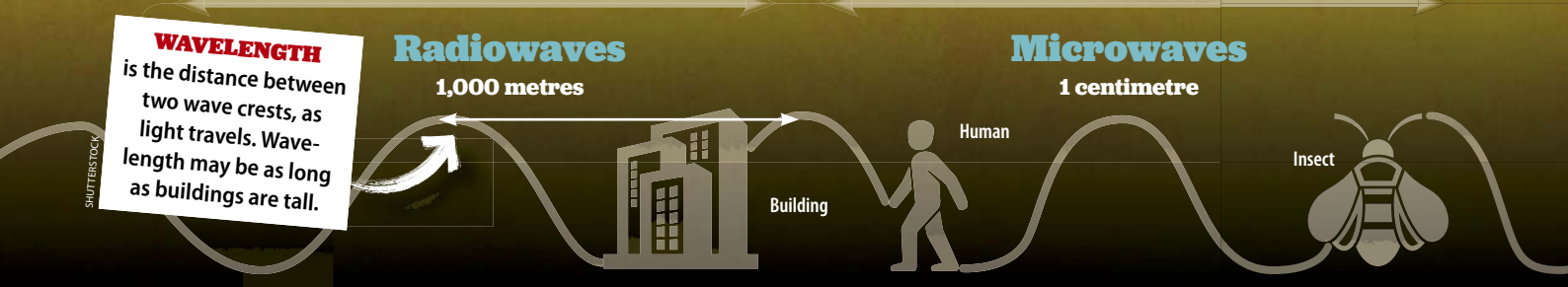
Waves heat your dinner

SHUTTERSTOCK

In a microwave oven, dinner can be heated very fast by means of high-energy microwaves. A vacuum tube at the top of the oven produces the tiny waves that spread throughout the oven. The radiation hits the food and is captured by magnetic molecules such as water molecules. The energy from the microwave radiation makes the water molecules rotate themselves and rub against the other food molecules. The friction converts the energy from the water motion into thermal energy, making the temperature of the food rise considerably and very fast.

WAVELENGTH is the distance between two wave crests, as light travels. Wavelength may be as long as buildings are tall.

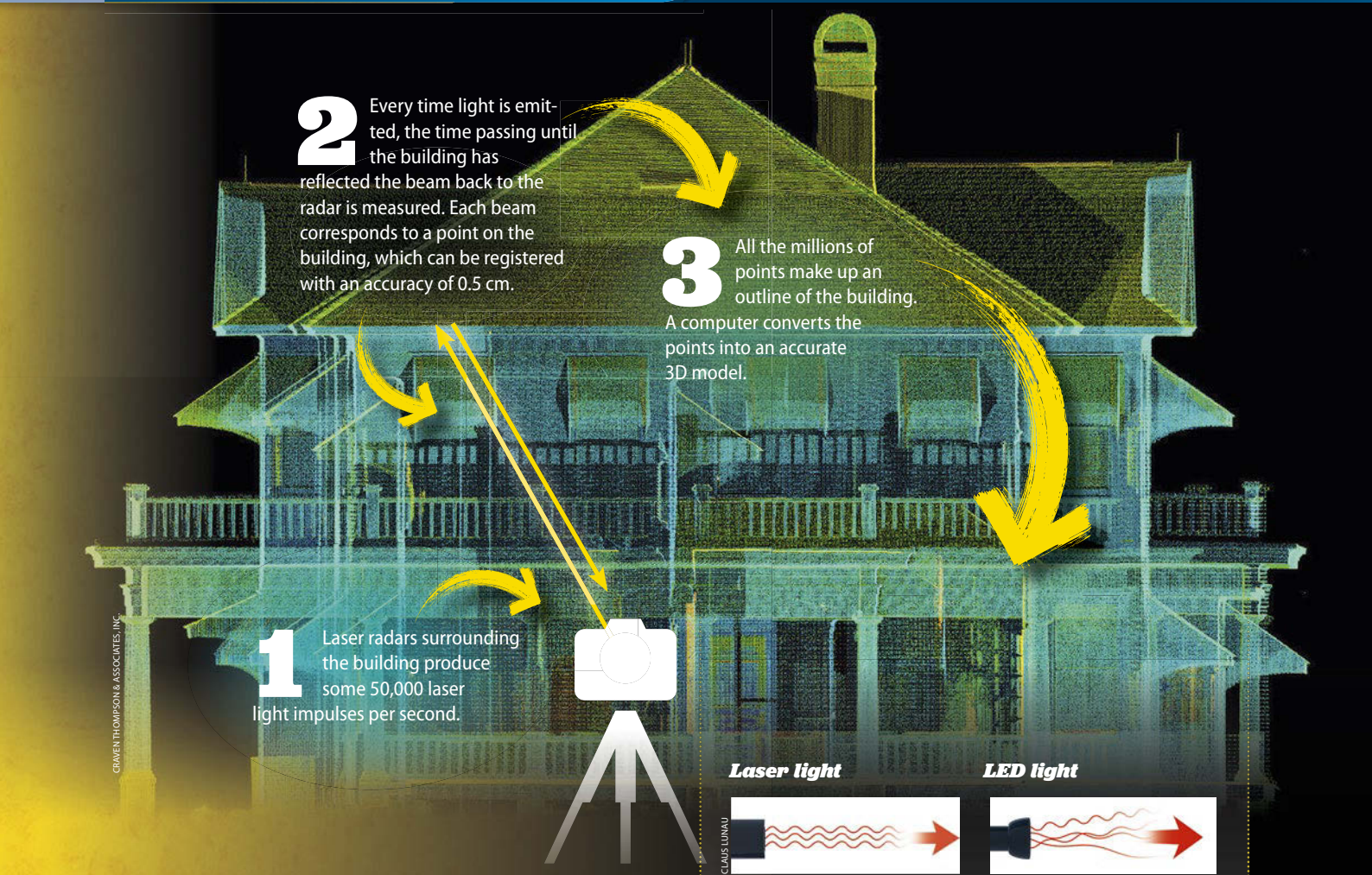
SHUTTERSTOCK



The Dutch Railways intend to use laser light to get rid of dead leaves. The leaves are a major problem, as the heavy trains compress the leaves into a sticky substance, affecting the train service. The powerful laser beams detach the leaves from the tracks, cutting them into tiny pieces.

SHUTTERSTOCK

The UN named 2015 the Year of Light, *expecting many new bright ideas to be born in the future.*



2 Every time light is emitted, the time passing until the building has reflected the beam back to the radar is measured. Each beam corresponds to a point on the building, which can be registered with an accuracy of 0.5 cm.

3 All the millions of points make up an outline of the building. A computer converts the points into an accurate 3D model.

1 Laser radars surrounding the building produce some 50,000 laser light impulses per second.

CRAVEN THOMPSON & ASSOCIATES, INC.

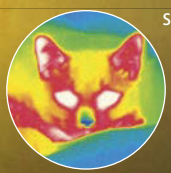
CLAUS LUNAU

Laser measures structures

An ordinary bulb emits light helter-skelter. The waves feature different lengths, and they do not oscillate in sync. In a laser, the light is highly organised. All light waves have the exact same wavelength, and they oscillate in sync like the legs of marching soldiers. This makes the organised laser beams a fantastic measuring instrument, which can produce detailed 3D models of cultural structures in decay. The virtual copies of a decaying Inca temple can be used as templates in connection with repair or reconstruction.

Camera sees in the dark

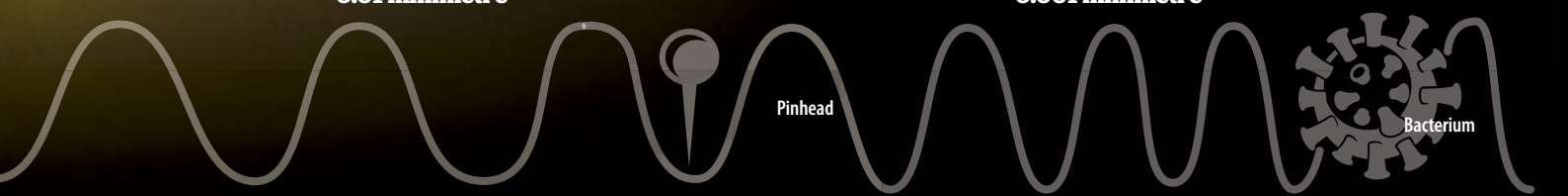
A heat-sensitive camera can take photos of humans and animals although it is pitch-dark. All objects with a temperature of between 1 and 1,400 degrees shed heat by emitting the energy as light – so-called infrared radiation. An infrared camera depicts the radiation by means of sensors which can register the wavelengths at which heat radiation is emitted. In the photos, the warmest surfaces are red and yellow, whereas the coldest areas are green or blue.



IMAGESELECT

Infrared light
0.01 millimetre

Visible light
0.001 millimetre



Did you know that

electromagnetic

every form of light is emitted in the shape of radiation? Though light particles are neither electrically charged nor magnetic in themselves, a light wave still produces both an electric and a magnetic field around it. That is because light, electricity, and magnetism are all manifestations of the force of nature known as electromagnetism.

CLAUS LUNAU

UV light panels determine the direction of the radiation in the room.

2 A UV lamp emits a broad field of ultraviolet light along the ceiling. As the warm breath moves upwards, the light hits the bacteria, destroying their DNA, so they die.

Bacteria

1 The patient's expired air is full of bacteria that pollute the air. The bacteria spread across the room, where they may infect other patients.

SHUTTERSTOCK

3 The purified air is distributed across the room by the ordinary air circulation, involving no risk of spreading bacteria among patients.

UV light removes bacteria from air

Ultraviolet light features such a short wavelength and so much energy that it can hit and enter tiny organisms such as bacteria, to which the radiation may cause severe damage. The light can kill the bacteria by destroying the vital functions of cells. Other tiny organisms are affected by the radiation in the same way as we may be by UV radiation from the Sun, which can cause mutations and cancer. But instead of making the organism sick, the radiation alters its DNA, so it cannot reproduce and spread more disease.

The bacteria-killing qualities of UV light can be used in hospitals to disinfect air, so patients will not infect each other. The rays can also be used on food and to purify the water of swimming facilities. UV light purification was one of the first acknowledged methods of disinfection, but the method was given up, because it was easier to use chemicals such as chlorine for purification.

Rays see right through you

X-ray equipment functions as a camera, but instead of visible light, the device uses X-rays to take photos. X-rays feature shorter wavelengths and higher frequencies, providing the rays with so much energy that they penetrate the body. En route, fat, bones and tissue absorb the rays to different extents. The result is a photo of the inside of the body, in which different parts have different shades.

SHUTTERSTOCK

Ultraviolet light
10 nanometres (10^{-8} m)

X-radiation
0.1 nanometre

Molecule

Atom

Sunlight is a prerequisite of life on Earth. All plants survive by converting solar energy into organic material via photosynthesis, and animals and humans feed on plants.

SHUTTERSTOCK

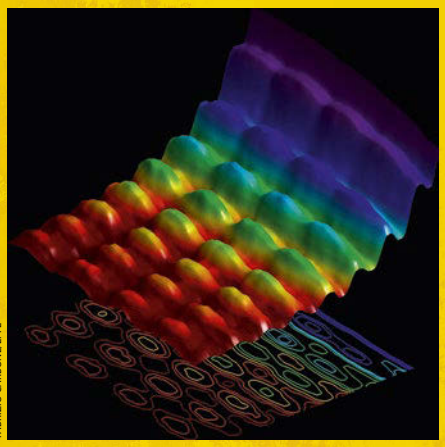
Test your knowledge about light

1 Does anything in the universe travel faster than light?

2 Does light consist of particles or waves?

3 Is visible light the only type of light?

ANSWERS 1: No. The speed of light of 299,792,458 metres per second is the top speed in the universe. 2: Both. Light is both particles and waves. 3: No. The term light covers the entire electromagnetic spectrum from radio waves to gamma rays.



FABRIZIO CARBONE/EPFL

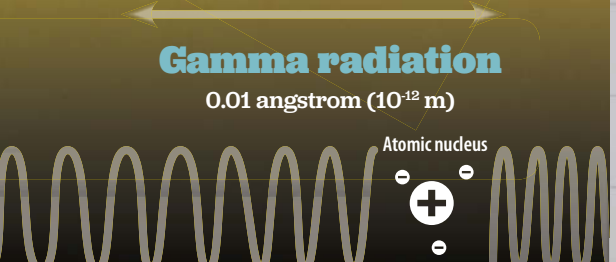
Researchers shooting light

Light is a particle and a wave, and this dual-personality is vital for our understanding of quantum computers. Scientists at the EPFL labs in Switzerland have finally "photographed" light acting simultaneously as a particle and a wave. The key? Using so-called nanowires... and a dose of extreme cleverness.

Substance makes cancer light up

Radioactive substances emit gamma radiation, and the tiny, bright waves can be used to detect cancer. When the substance is injected into the body, it is absorbed by cells. Sick cells have higher metabolisms than normal cells, and so, they absorb more of the radioactive substance. Doctors can see the distribution of the substance in the body on scans, where areas with cancer cells will light up.

SHUTTERSTOCK



From reflection to X-rays

300 B.C. >> 1637

According to Greek mathematician ***Euclid***, light travels in straight lines. He discovers the laws of light reflection and finds the mathematical proof.

GETTY IMAGES

French philosopher ***René Descartes*** claims that light travels in waves. His conclusion is based on light moving forwards in the same way as sound waves.

1905 >> 1958

Albert Einstein develops a theory describing that light is not only waves, but also consists of light quantums, which are tiny particles.

Solar cells are first used by the American Vanguard satellite, directing power for the satellite. Today, most satellites are equipped with solar panels.

NASA

1960 >> 1981

American physicist ***Theodore Harold Maiman*** builds the world's first laser, which is not used for practical purposes until a much later date.

ARCHIVE

The US company ***General Electric*** makes a 40 km fibreoptic cable. The cable is the precursor of modern international optical fibre networks used for communication purposes.

2017 Laser films molecules

The world's biggest and most sophisticated X-ray laser is ready for the first experiments to be made in two years. Known as XFEL, the laser is a 3.4-km-long accelerator, which will produce the world's most powerful X-rays, emitting the latter in ultrashort pulses of one millionth of a billionth of a second. The powerful and fast rays can take photos or record short films of molecules at work. For instance, they are able to capture ultrafast chemical reactions like when plants perform photosynthesis, and they can observe how individual atoms of a particular drug behave, as they enter cells.

11 countries have built the new X-ray laser in Hamburg, Germany.

XFEL

NANO DRUGS BLOW UP CANCER

By Rasmus Kragh Jakobsen

Nanoparticles catch cancer cells off-guard. The particles are stage one of a four-stage rocket of lasers, explosions, drugs, and X-rays. The new method, which destroys cancer from within, has cured mice with fatal neck cancer.

SHUTTERSTOCK

A targeted gold particle flows through the blood vessels. Soon, it will aim for a cancer cell. Just like a military missile, the tiny gold particle locks on to the target. Very accurately, the gold particle attacks the cancer, killing the malicious cell. The war is fought in such a tiny battle field that if the gold particle were enlarged to the size of a football, the microscopic cancer cell would be the size of the whole football pitch.

Known as quadrapeutics, the new, breakthrough method was developed by nanoscientist Dmitri Lapotko and his colleagues from the American Rice University. The scientists have demonstrated that they can kill even the most aggressive of cancer tumours that cannot be knocked out by existing drugs. And with-out harming the surrounding healthy cells, as the method only attacks cancer.

CELLS TURN AGAINST US

Scientists have long been able to smuggle nanoparticles with anti-cancer drugs into cancer cells. The mechanism is used in existing cancer nanodrugs, but Lapotko and his colleagues go one step further, bombing the cancer from within. The central elements of the technology are tiny gold nanoparticles, which are about 1/10,000 of the diameterof a human hair. The particles must be nanoscopic in order to sneak into the cell. If they were much bigger, the cell would not allow them to enter.

CANCER REVEALED BY MARKERS

Even today, cancer is extremely difficult to combat, because existing treatments often involve severe side effects, as anti-cancer drugs have a devastating effect on healthy body cells. Cancer is our own cells turning against us. The control mechanisms inside cancer cells, which would normally prevent cell division, are broken, so the cell divides with all its might. The problem is that in many ways, cancer cells are like the body's own cells, and so, they are very difficult to spot. The tumour can be removed, but often, it has mixed with healthy tissue, which doctors may injure during surgery. Consequently, doctors need a tool ▶

NANODRUGS ON THE RISE

Several types of nanomedication are already available. Most of them are designed to affect the very mechanism which makes cancer different from healthy cells.

BREAST CANCER

APPROVED IN SEVERAL COUNTRIES

NAME: Abraxane

NANOMETHOD: The drug consists of 10 nm capsules of albumin blood protein with nano-medicin inside. The human body uses natural albumin for transport purposes. The capsules bind to the SPARC tumour marker, and subsequently, the medicine kills the cancer cell.

BONE CANCER

APPROVED IN THE PHILIPPINES

NAME: Rexin-G

NANOMETHOD: Rexin-G is 100 nm fat bubbles with a so-called immune factor attaching to connective tissue, which has been exposed by the cancer. The bubbles accumulate in the tumour, releasing tiny microRNA, which destroys a specific gene and halts cell division.

LUNG CANCER

TESTED ON HUMANS

NAME: Aurimune

NANOMETHOD: Gold nanoparticles with the TNF signal molecule locate and bind to cancer cells. TNF destroys the blood supply inside the tumour, killing the cell. TNF also breaks down the tumour's defence mechanisms, providing easier access for other medication.

New nanomedication focuses on the weak spots of cancer cells. One of the latest methods uses gold as a Trojan horse to blow up the cancer from within.

▶ that can kill cancer from within. In recent years, nanotechnology has inspired new hope, as the tiny particles can hit individual cells with tiny, targeted, drug-laden nanomissiles. This means that doctors can treat each individual tumour cell with a much higher dose of toxin than they traditionally can, and in the process, they can avoid affecting healthy tissue.

Most conventional types of anti-cancer drugs – so-called chemotherapy – destroy cancer cells' ability to divide. But chemotherapy is a powerful cytotoxin, which also affects healthy cells that often divide – such as blood, hair, and intestinal cells. So, scientists have long been searching for specific, molecular cancer cell characteristics that make them different from other cells.

Now, scientists have found a series of so-called tumour markers, i.e. a specific group of proteins that exist on the surfaces of cancer cells, but hardly on healthy cells: the perfect targets.

The proteins on the cancer cells seize signal molecules such as antibodies. So, scientists have designed special anti-bodies that can seize a tumour marker known as an EGF receptor. The bond makes two EGF receptors clump together, prompting the cancer cell to allow the antibody to enter. Normally, the mechanism is a signal that the cell should divide, but the scientists' antibodies mean that the cancer is in for a surprise, as gold nanoparticles have been attached to the antibodies, which will soon kill the cancer from within.

PARTICLES TRIGGER EXPLOSIONS

Once the gold particles – scientists' version of the Trojan horse – have entered, the particles are heated from the outside by means of laser. The heating triggers explosions, blowing holes in the cancer cells. When the gold nanoparticles are hit by laser light, a so-called plasmonic effect is produced, by which the laser light makes the free electrons of the metal oscillate in sync with the frequency of the light. The oscillations heat the gold particle in a split second, making the liquid surrounding it evaporate. The energy of the laser light is concentrated in the gold, i.e. it does not harm healthy cells. The vapour produces a bubble that collapses, and the energy is so intense that the cell is torn apart. Scientists take advantage of the fact that cancer cells absorb many gold particles, allowing them to adjust the laser energy, so the explosion is not triggered, until many gold particles have accumulated in one cell. In this way, they will not harm healthy cells that have absorbed gold particles by mistake.

> **One single quadrapeutics treatment eliminates tumours in one week...**

With the targeted missile, therapy can be changed from a general carpet bombing of the body involving severe side effects into a targeted attack on individual tumours' biological characteristics.

EXPLOSIONS RELEASE MEDICATION

The gold nanoparticle explosions kill the cancer cells, but to make sure that no malicious cells survive the attack, Lapotko and his colleagues combine the me-thod with X-radiation and chemotherapy.

The gold nanoparticle injection also contains medicine encapsulated in oil droplets. The oil "wrapping" makes sure that the medication has no effect and is harmless in the body. The medicine is not released until the explosion rips the tiny oil droplets apart. So, the cytotoxin is only activated locally, near the tumour, and flows into the cancer cell via holes.

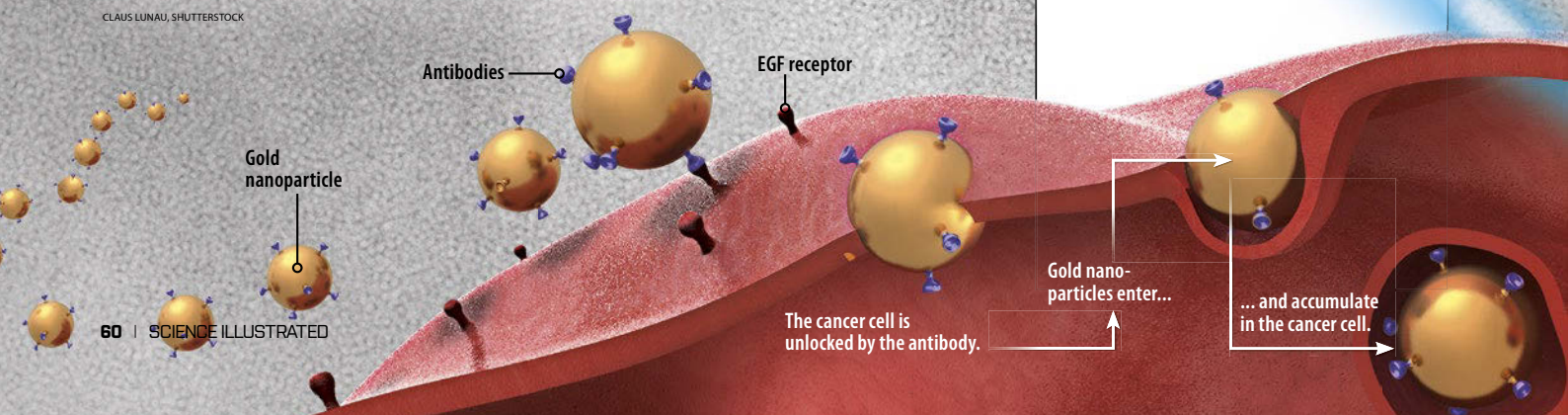
4-STAGE CANCER ATTACK

A new method known as quadrapeutics enables doctors to attack cancer cells from within. Specific molecules locate the cancer cells and make them allow "bombs" and medication into their interiors.

CLAUS LUNAU, SHUTTERSTOCK

ANTIBODIES UNLOCK THE CANCER CELL

1 Gold nanoparticles are injected into the body. The particles are lined with so-called antibodies, which bind to EGF receptors - a kind of cellular "keyholes". Only the right antibodies match the EGF receptors, which exist in great numbers on cancer cells, but not on healthy cells. The bond makes the cell absorb the gold particles, which slowly accumulate.



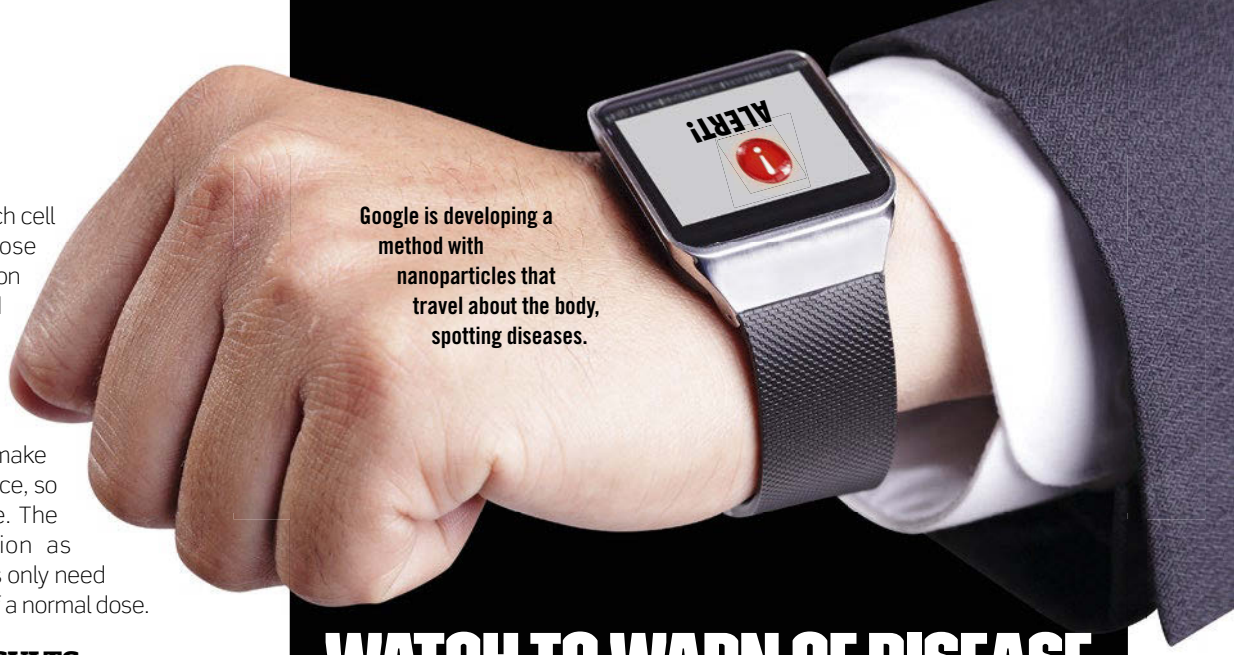
This means that each cell gets a much higher dose than when the medication is instead introduced intravenously to the entire body. The last quadrapeutics weapon is X-rays aimed at the tumour. X-rays make the DNA string cross-lace, so the cells cannot divide. The gold particles function as "amplifiers", i.e. doctors only need to use a few per cent of a normal dose.

IMPRESSIVE RESULTS

In experiments with mice suffering from head and neck cancer, Lapotko's group has shown that just one quadrapeutics treatment eliminates tumours in one week. This indicates that the method is up to 17 times more efficient than traditional chemotherapy and radiation, even when scientists only used 3 % of a normal dose of medication and 6 % of X-rays.

Quadrapeutics can probably kill many types of cancer, including brain, lung, and prostate cancer, and mice experiments are carried out, followed by human ones.

The successful mice tests promise that the method could convert a cancer diagnosis from a death sentence into a harmless disease such as pneumonia. SCI



Google is developing a method with nanoparticles that travel about the body, spotting diseases.

WATCH TO WARN OF DISEASE

In Google's secret lab, Google X, scientists are developing a pill including nanoparticles that can travel about the body, spotting several diseases, such as cancer. The aim is to prevent disease instead of treating it. First, the user must swallow a pill with magnetic nanoparticles that travel about the body with the blood. The nanoparticles are lined with so-called antibodies, allowing them to recognize and bind to cancer cells. At the wrist, the nanoparticles are attracted to a magnet placed in an electronic watch, bracelet, etc. The watch automatically "reads" the particles and sounds the alarm, if they have located cancer cells.

Several groups of scientists are developing similar nanosystems that can detect signs of diabetes, coronaries, HIV, etc. The nanoparticles are introduced into the blood stream and bind to substances or cells, after which doctors test the nanoparticles' findings.

Google X

SHUTTERSTOCK

LASERS BLOW UP THE CANCER CELL

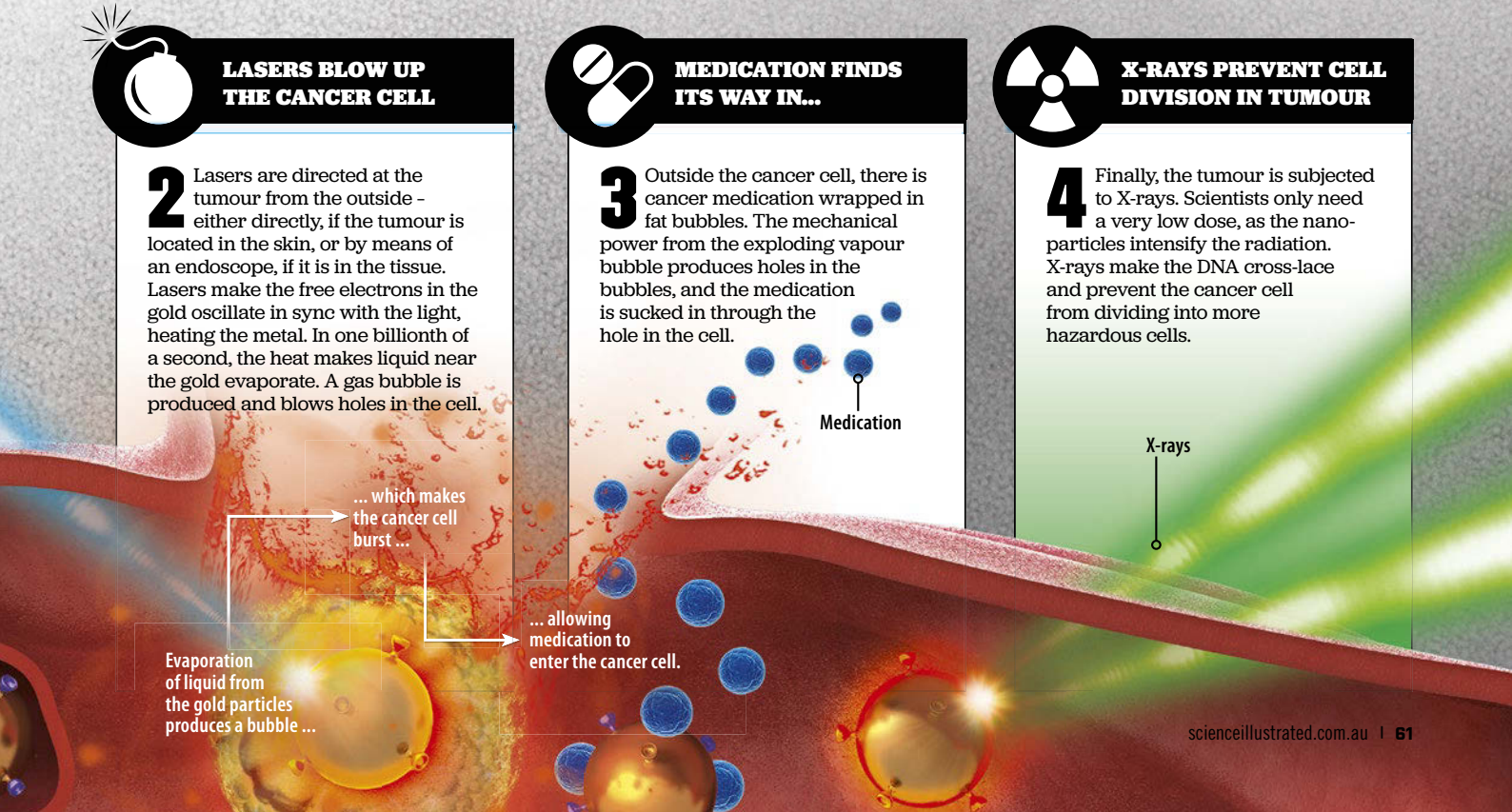
2 Lasers are directed at the tumour from the outside – either directly, if the tumour is located in the skin, or by means of an endoscope, if it is in the tissue. Lasers make the free electrons in the gold oscillate in sync with the light, heating the metal. In one billionth of a second, the heat makes liquid near the gold evaporate. A gas bubble is produced and blows holes in the cell.

MEDICATION FINDS ITS WAY IN...

3 Outside the cancer cell, there is cancer medication wrapped in fat bubbles. The mechanical power from the exploding vapour bubble produces holes in the bubbles, and the medication is sucked in through the hole in the cell.

X-RAYS PREVENT CELL DIVISION IN TUMOUR

4 Finally, the tumour is subjected to X-rays. Scientists only need a very low dose, as the nanoparticles intensify the radiation. X-rays make the DNA cross-lace and prevent the cancer cell from dividing into more hazardous cells.



SUBSCRIBE
for your chance to win!

1 of 2 CROSSOVER 25 LITRE BACKPACKS FROM **THULE!**

WORTH **$169.95** EACH!

The Thule Crossover™ 25 Litre Backpack for the 15" (or smaller) MacBook Pro is designed for gear-heads who need dedicated **electronics protection,** plus pockets and compartments for whatever the day might bring. It features a padded, integrated **laptop compartment** that holds up to a 15 inch MacBook Pro, crush proof **SafeZone™** compartment for your sunglasses, iPhone, portable electronics and other fragile gear. The SafeZone™ compartment can be locked or removed for extra room and the die-cut EVA shoulder straps, with mesh covering, provide ventilation and breathability. Made from lightweight protective water-resistant materials and zippers with a **25 Year warranty.**

Thule – Bring your life
www.thule.com

THULE® SWEDEN

Every issue of Australian Science Illustrated includes news and features on:

- New science discoveries
- Astronomy, cosmology and the universe
- Plant and animal biology
- Archaeology and palaeontology
- History and culture
- Green technology and renewable energy

And much more!

Subscribing to Australian Science Illustrated gives you these benefits!

- ✓ Save over 28% on the retail price!
- ✓ Never miss an issue!
- ✓ Get the mag delivered right to your door!
- ✓ Save even more if you subscribe for two years!

ORDERING YOUR SUBSCRIPTION IS EASY

mymagazines.com.au

Call 1300 361 146 or
02 9901 6111

Mail
Science Illustrated
Locked Bag 3355
St Leonards NSW, 1590

SCIENCE
ILLUSTRATED

YES! I WOULD LIKE TO SUBSCRIBE STARTING WITH THE NEXT AVAILABLE ISSUE

☐ **Me** ☐ **Gift**

☐ **2yr subscription** (12 issues)
$84.95 SAVE OVER 28%

☐ **1yr subscription** (6 issues)
$44.95 SAVE OVER 24%

☐ **3 ISSUES / 6 MONTHS**
$22.95 SAVE OVER 23%

Best value

YOUR DETAILS

MR/MRS/MS/MISS Name: _____

Address: _____

_____ **State:** _____ **Postcode:** _____

Email: _____

Phone: ( ) _____

PLEASE PROVIDE PHONE OR EMAIL IN CASE OF DELIVERY ISSUES

GIFT RECIPIENT DETAILS

MR/MRS/MS/MISS Name: _____

Address: _____

_____ **State:** _____ **Postcode:** _____

Email: _____

Phone: ( ) _____

PAYMENT DETAILS

I enclose a Cheque / Money Order for AU$_____ payable to NextMedia pty ltd

OR

Please charge $_____ to ☐ VISA ☐ MasterCard

Card holder's name: _____

Card number: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Expiry date: ☐☐ / ☐☐

Signature: _____

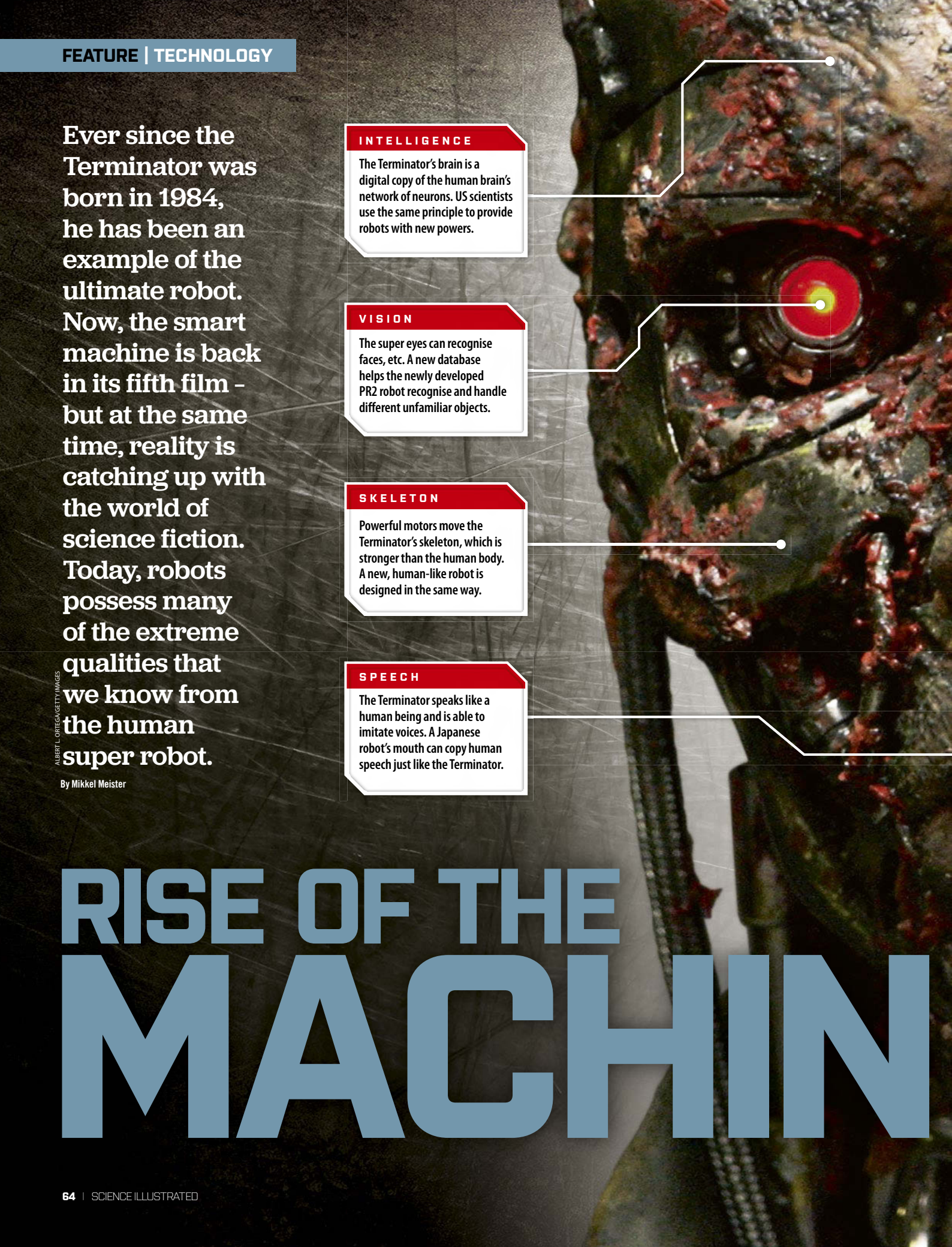
Terms and conditions: Price offer available to Australian and NZ residents. Expires 12/8/15. Includes GST. Savings based on total cover price. Overseas Airmail 12 issues A$198 or 6 issues A$99. This form may be used as a Tax Invoice. nextmedia Pty Ltd ABN 84 128 805 970. Competition open to Australian and NZ residents subscribing to Science Illustrated for a minimum 1 year. Open 00:01 AEST 18/6/15 and closes 23:59 AEST 12/8/15. 2 lucky subscribers will receive a Thule Crossover backpack, prize valued at $169.95. Total prize pool is $339.90. The winners will be drawn at the Promoter's premises on 18/8/15. The Promoter is nextmedia Pty Ltd 207 Pacific Hwy, St Leonards, NSW 2065. Permit Numbers NSW Permit No. LTPM/14/01394, ACT Permit No. TP 14/04530. For full terms and conditions please visit www.mymagazines.com.au Please tick if you do not wish to receive special offers or information from nextmedia or its partners via ☐mail ☐email. Please refer to www.nextmedia.com.au for the full Privacy Notice.

MA/37

RISE OF THE MACHIN

Ever since the Terminator was born in 1984, he has been an example of the ultimate robot. Now, the smart machine is back in its fifth film – but at the same time, reality is catching up with the world of science fiction. Today, robots possess many of the extreme qualities that we know from the human super robot.

By Mikkel Meister



ALBERT L. ORTEGA/GETTY IMAGES

INTELLIGENCE

The Terminator's brain is a digital copy of the human brain's network of neurons. US scientists use the same principle to provide robots with new powers.

VISION

The super eyes can recognise faces, etc. A new database helps the newly developed PR2 robot recognise and handle different unfamiliar objects.

SKELETON

Powerful motors move the Terminator's skeleton, which is stronger than the human body. A new, human-like robot is designed in the same way.

SPEECH

The Terminator speaks like a human being and is able to imitate voices. A Japanese robot's mouth can copy human speech just like the Terminator.

CALCULATOR

The Terminator can quickly calculate distances and the speed at which objects move. Today, a robotic dog uses the technique to keep its balance.

HEARING

One ear picks up all sounds from the surroundings. The other ear focuses on and analyses selected sounds just like a Japanese robot does in reality.

EMOTIONS

The Terminator does not have emotions, but interprets and considers people's emotions in the same way as Pepper the robot does with its owner's.

SKIN

The skeleton is covered by synthetic skin, so the Terminator looks like a human being. Today, scientists can create geminoids -- copies of living people.

ES

This year, the Terminator will be back in cinemas in "Terminator: Genisys".

UP

For more than 30 years, the Terminator has appeared on cinema screens and TVs: a metallic killer robot the size of a man covered by human-like skin and hair. Dispassionately, it analyses any situation, calculates the possible outcomes, and acts accordingly to achieve its goal. The story about the Terminator is the story about the ultimate robot, that can very accurately copy the way in which people act and talk, and which boasts superhuman vision and hearing. On top of the Terminator's extreme strength and sophisticated computer brain, those qualities have so far placed the robot in a distant, futuristic world. But now, technology is catching up with reality; a reality, in which robotic qualities are just as good as human ones – and some-times even better.

Robots are specialists Robotics scientists do not aim to copy of the Terminator robot that we know from films, where all extreme qualities are united in one single robot. But every individual Terminator capacity is useful in robots, which are meant to work in specific environments or carry out special functions. Consequently, scientists throughout the world are working hard to design robots that specialize in different disciplines – recognizing objects on a conveyor belt, calculating how to keep their balance in impassable territory such as disaster sites, or interpreting people's emotions and reacting accordingly.

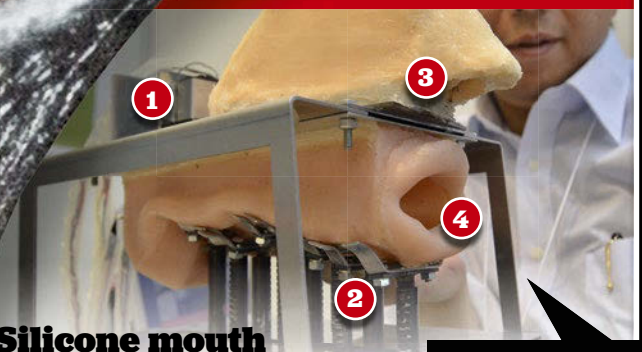
One example of scientists' efforts is the 130-cm-tall, Japanese, human-like Honda Asimo robot, which is so far able to run, hop on one leg, pour tea from a thermos, etc. Many ordinary everyday tasks remain a challenge, but in the end, Asimo is meant to become sufficiently independent to help elderly, sick, or disabled people in their homes.

Other scientists are refining the robots' hearing. Today, the GPS units of many cars can react to speech commands, but if there is noise, the message is not received. With improved technology, robots will be able to take messages, even through a thick curtain of background noise.

COMPUTERS TO TAKE OVER THE WORLD

Quite a lot of robotics science is about developing artificial intelligence, which can enable robots to think like humans, but ▶

SPEECH



Silicone mouth copies human sounds

Japanese scientists have built a robot that copies the way in which humans speak. Like humans, the robot has lips, throat, nose, lungs, and vocal chords, allowing it to produce the same sounds as we can. Without teeth, it cannot pronounce s and f sounds, and the voice cannot express moods.

SIMPLE ROBOT — TERMINATOR

1 An air pump functions as artificial lungs.
2 8 pistons below the throat regulate the air according to the sounds produced by the mouth.
3 A nose valve adjusts the air flow, allowing m and n sounds.
4 The silicone mouth copies the motions made by a human mouth.

YOSHIKAZU TSUNO/AFP/SCANPIX

HEARING

Robot hears better than humans

Honda's HEARBO robot can distinguish between up to seven different sound sources at once, whish is better than human hearing. Its microphones very accurately register where the sounds come from, analysing their nature. For instance, the robot can recognize music by identifying beats per minute, and it is able to understand human speech by converting it into text.

SIMPLE ROBOT — TERMINATOR

HEARBO boasts 8 mics located on its head.

CLAUS LUNAU

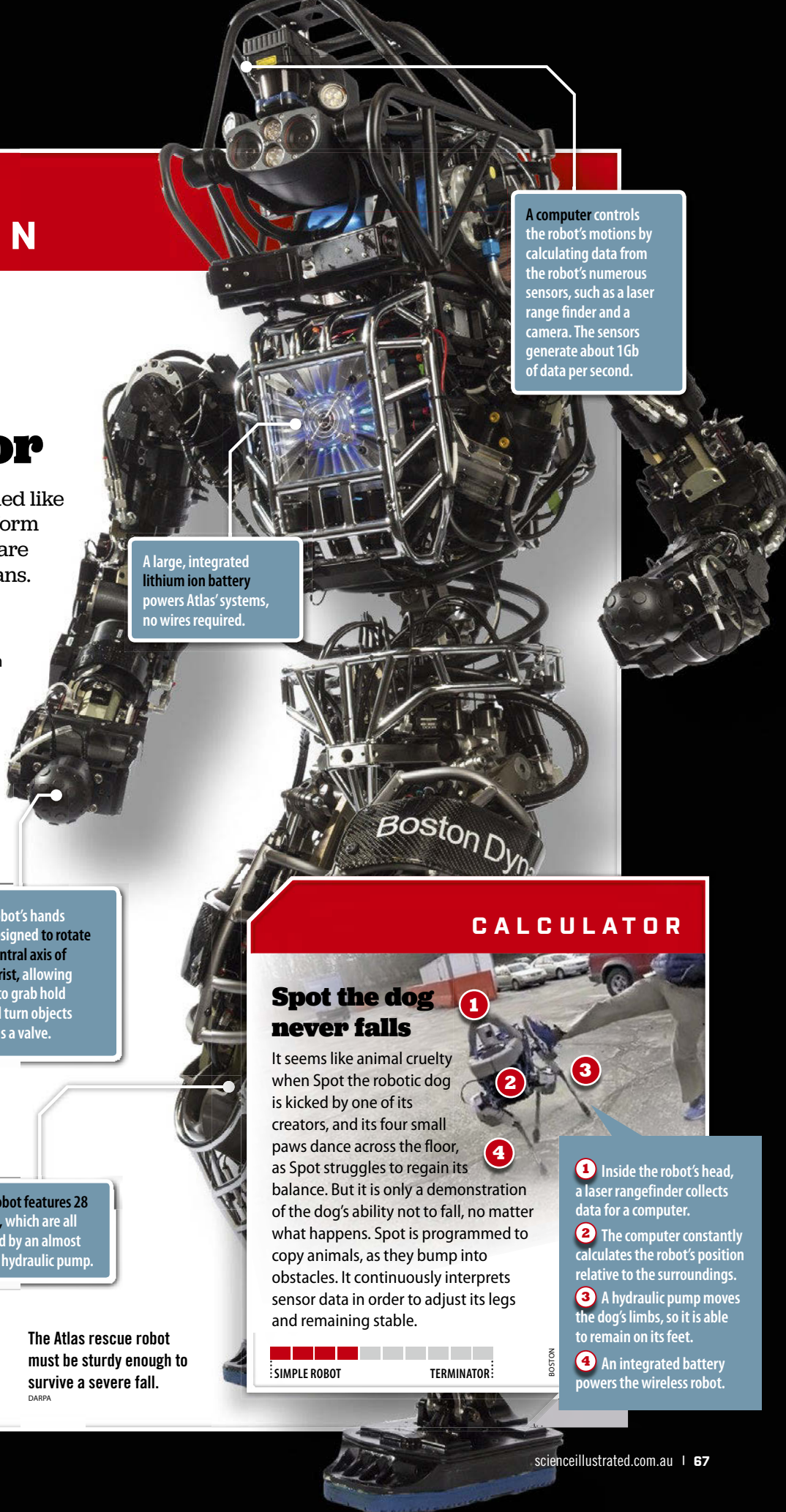
SKELETON

Atlas is a real Terminator

The US Atlas robot is designed like a human body and can perform rescue operation tasks that are usually carried out by humans.

It does not speak English with the Terminator's familiar, heavy Austrian accent, but the resemblance between the Terminator and the Atlas robot is striking. Atlas is a so-called humanoid – a robot built like a person with arms, legs, feet, torso, and head. The American company Boston Dynamics and the DARPA research agency are responsible for the big, 188-cm-tall, and 156.5-kg-heavy Atlas robot. The project aims to produce a robot which can assist people in connection with rescue missions or independently save lives in disaster areas. The first prototype from 2013 featured the motor functions of a 1-year-old baby, but since then, 75 % of the robot's parts have been replaced and its computer updated. The new, improved Atlas robot can avoid obstacles on the ground, walk up stairs, jump off edges, and keep its balance on one leg, although it is pushed.

SIMPLE ROBOT — TERMINATOR



A computer controls the robot's motions by calculating data from the robot's numerous sensors, such as a laser range finder and a camera. The sensors generate about 1Gb of data per second.

A large, integrated lithium ion battery powers Atlas' systems, no wires required.

The robot's hands are designed to rotate the central axis of the wrist, allowing Atlas to grab hold of and turn objects such as a valve.

The robot features 28 joints, which are all moved by an almost silent hydraulic pump.

The Atlas rescue robot must be sturdy enough to survive a severe fall.
DARPA

CALCULATOR

Spot the dog never falls

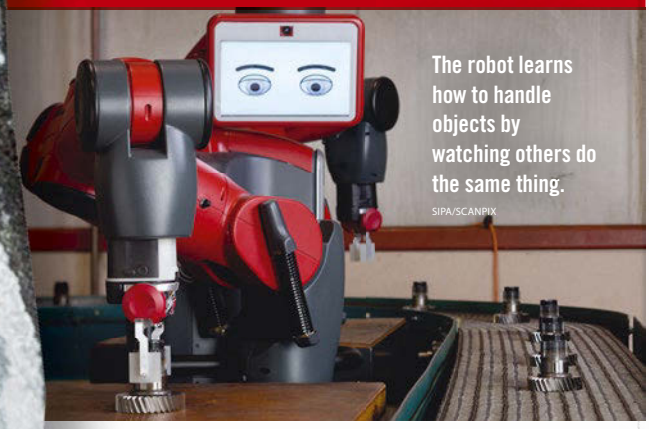
It seems like animal cruelty when Spot the robotic dog is kicked by one of its creators, and its four small paws dance across the floor, as Spot struggles to regain its balance. But it is only a demonstration of the dog's ability not to fall, no matter what happens. Spot is programmed to copy animals, as they bump into obstacles. It continuously interprets sensor data in order to adjust its legs and remaining stable.

SIMPLE ROBOT — TERMINATOR

BOSTON

1. Inside the robot's head, a laser rangefinder collects data for a computer.
2. The computer constantly calculates the robot's position relative to the surroundings.
3. A hydraulic pump moves the dog's limbs, so it is able to remain on its feet.
4. An integrated battery powers the wireless robot.

INTELLIGENCE



The robot learns how to handle objects by watching others do the same thing.

SIPA/SCANPIX

Computer works like the human brain

At the US University of Maryland, scientists are teaching a robot new tricks by making it watch YouTube videos of people cooking food, etc. The robot's computer uses a copy of the complex network of neuron links in the human brain to learn new things. By watching the chef videos, the robot may learn enough to be able to cook a meal for the scientists who are devloping it.

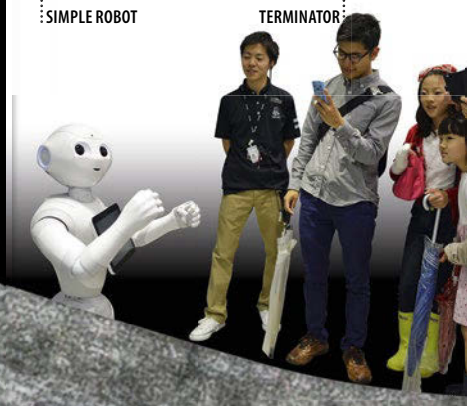
SIMPLE ROBOT — TERMINATOR

EMOTIONS

Pepper interprets emotions

The Japanese company Softbank has developed a robot named Pepper, which uses cameras and mikes to interpret people's emotions based on their facial expressions, body language, and voices. Pepper is a social robot intended for private households. It can dance, react to touch, compliment your clothes, shake hands, have simple conversations, and check weather reports and share prices online. New abilities can be installed in the same way as apps can be downloaded to a smartphone.

SIMPLE ROBOT — TERMINATOR

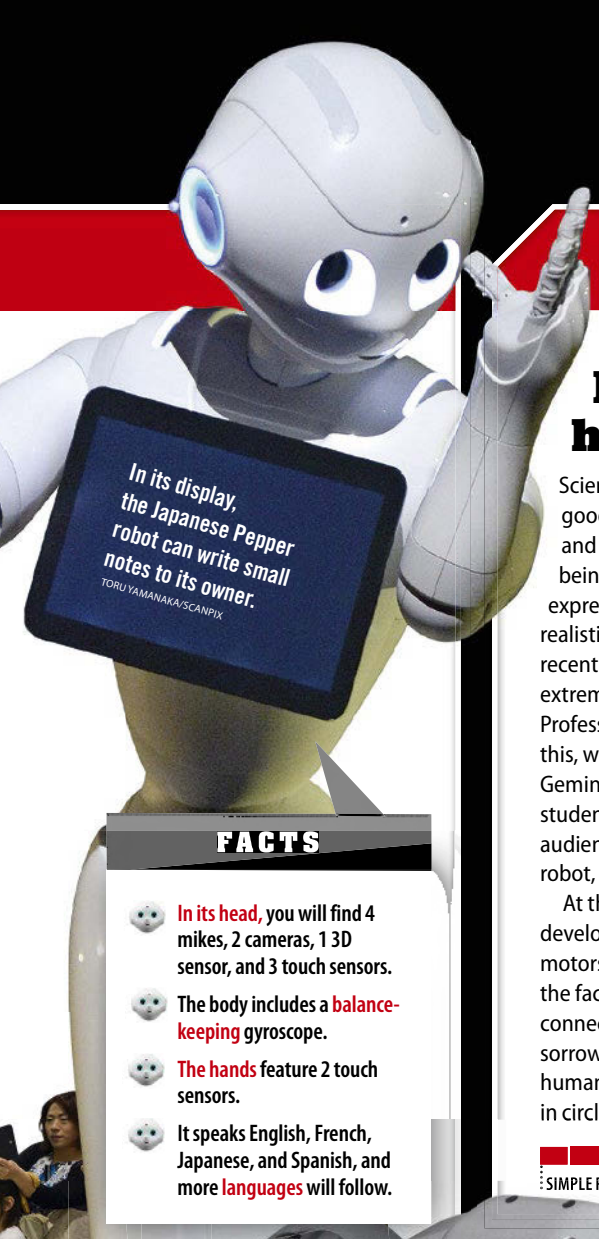


▶ that may also give rise to worries, in case the robots become too sophisticated, according to famous physicist Stephen Hawking and entrepreneur Elon Musk: the man behind the electric sports cars from Tesla. Well-developed artificial intelligence could prove superior to human intelligence, and according to critics, there is no guarantee that intellectually superior robots will be kindly disposed to their inferior, biological creators.

The fear of what the intelligent robots may do is consistent with the future scenario on which the five Terminator films are based. In the early 21st century, the global military computer programme Skynet becomes able to think like a human being. The creators of the programme panic and try to shut it down, fearing what it will do with its newly found intelligence, but Skynet sees through the plan, and like a digital army commander, the programme decides to make the first move. Once the dust of the battle has settled, the people who survive face a computerized dictatorship enforced by an army of titanium-shining, deadly Terminators.

The critics do not go this far, but according to Stephen Hawking, there is a real risk of a scenario, in which sophisticated artificial intelligence develops at an exponentially accelerating pace, which is very much superior to human evolution. Over time, we would become obsolete: like a Neanderthal compared to the synthetic super-humans of the future.

Other scientists are not quite as worried. The results of the artificial intelligence research carried out so far are already used to filter through spam e-mail and automatically recognize people in photos from Facebook and many other services that we employ in our everyday lives. In addition, a state-of-the-art, intelligent, and self-aware machine will not have been developed, until another 50 or 100 years or more have passed. Moreover, in our capacity as humans, we enjoy the huge advantage of being able to deactivate the robots, in case they display any evidence of intending to stage a revolt – or at least we do so far. SCI



SKIN

Robots resemble human beings

Scientists have become very good at making artificial skin and muscles, and a human being's looks and facial expressions can now be copied so realistically by robots that the most recent human-like robots are extremely life-like. Danish Professor Henrik Schärfe learned this, when his robotic clone, Geminoid DK, lectured a group of students. Not everyone in the audience realized that it was a robot, not the professor, sharing his knowledge.

At the University of Pisa in Italy, scientists have developed the FACE robot, which features 32 integrated motors in its head and neck, enabling it to copy some of the facial expressions produced by humans in connection with happiness, amazement, disgust, anger, sorrow, fear, etc. Unlike several of the muscles of a human face, the motors are, however, not able to move in circles, and so, the robot cannot copy all expressions.


JESPER GORM/POLFOTO

In 2011, Professor Henrik Schärfe had his own human-like robot, Geminoid DK.

FACETEAM.IT

The FACE robot features 32 motors under its skin, enabling it to copy human expressions.
FACETEAM.IT

SIMPLE ROBOT — TERMINATOR

FACTS

- **In its head,** you will find 4 mikes, 2 cameras, 1 3D sensor, and 3 touch sensors.
- The body includes a **balance-keeping** gyroscope.
- **The hands** feature 2 touch sensors.
- It speaks English, French, Japanese, and Spanish, and more **languages** will follow.

VISION

The P2 robot can learn how to hold a T-shirt and fold it.
WILLOW GARAGE/UC

1. The robot collects data about an object from a camera and a 3D sensor, passing it on to a server.

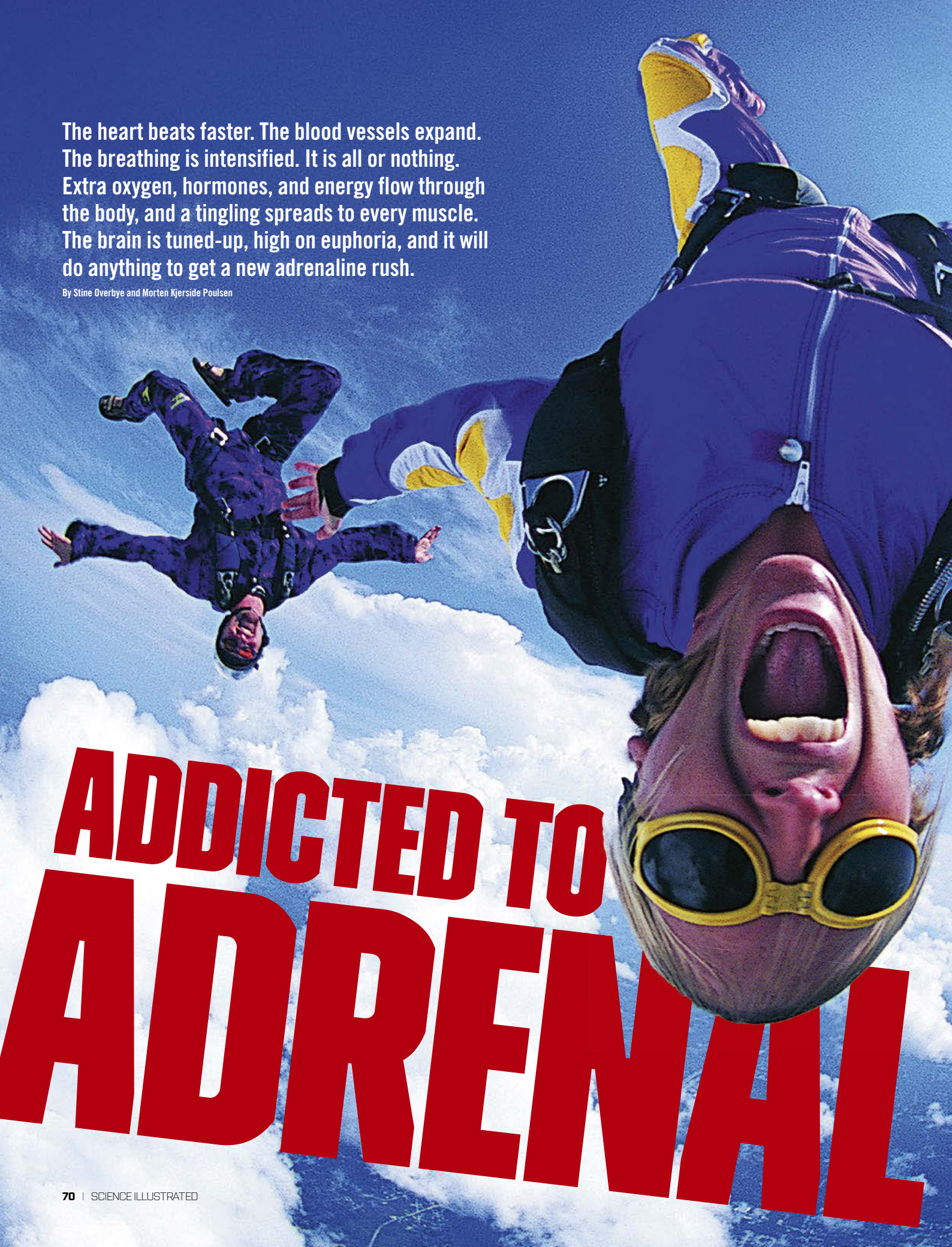
2. The server creates a 3D model and sends back information about the best way in which to handle the object.

3. The robot sends data back to the server about how it handled the object and how well it worked.

Robots improve each other's vision

The PR2 robot can pick up a plastic bottle without knowing its size or shape. The robot is assisted by a system which links a photo of the bottle from PR2 with information in a database, such as data about the size of the bottle and the force that the robotic hand requires in order to hold the bottle without losing it. Once the bottle has been picked up, the robot shares its experience with the server; knowledge that other robots can use later, when they are in the same situation.

SIMPLE ROBOT — TERMINATOR



ADDICTED TO ADRENAL

The heart beats faster. The blood vessels expand. The breathing is intensified. It is all or nothing. Extra oxygen, hormones, and energy flow through the body, and a tingling spreads to every muscle. The brain is tuned-up, high on euphoria, and it will do anything to get a new adrenaline rush.

By Stine Overbye and Morten Kjerside Poulsen

Adrenaline has the same effect as cocaine, and adrenaline junkies will stop at nothing to get the brain its next rush.
DIGITAL VISION/GETTY IMAGES

Slowly, Peter moves closer to the almost 1,000-m-deep abyss. He looks into the gorge, and though he has made the jump hundreds of times before, he cannot help being afraid. In a fever of excitement, he cautiously steps onto a rock ledge in his colourful wingsuit. He feels the wind in his face. For a short while, Peter considers turning back. But then he plucks up courage, counting down – 3, 2, 1 ...

Peter gives in to the adrenaline junkie inside him. He leans forward, feels his feet let go of the ground, and leaves the rest to gravity. At a staggering speed, he rushes through the air. His body is tensed up, his senses all alert, and he feels very much alive. Adrenaline pulses through his blood vessels, and his body is in a state of emergency, ready for action.

OUR ANCESTORS FLED

When we are in a stressful or potentially dangerous situation, large amounts of adrenaline are produced, preparing the body to fight or flee. Adrenaline is also known as the hormone of disaster, because it enables us to act promptly in situations which make extra demands on the body and its performance.

Faced with mammoths or sabre-toothed tigers, early humans' adrenaline production made sure that they were fit for fight or flight. In an instant, their bodies could go from being at ease to being highly alert. Our brains have not ▶

Five rushes for adrenaline junkies

1 BASE JUMPING

JUMP FROM A MOUNTAIN PEAK

BASE is short for buildings, antennas, spans (such as a bridge), and earth (such as mountain peaks). Base jumpers are death-defying daredevils, who jump from one of these solid objects. Most base jumps take place from an altitude of at least 500 m, but the limits are changing all the time. The closer to the ground the starting point is, the more dangerous the jump, as the parachute must unfold faster.

Some base jumpers use a wingsuit, i.e. a suit with wings from wrists to hips and between the legs, allowing them to glide. The suit increases the surface area of the body and so the lift. Base jumping and wingsuit jumping are highly dangerous extreme sports, and since 1981, some 250 jumpers have died after a cruel encounter with the ground.

Base jumpers wearing wingsuits can glide about 18km, allowing them to prolong their adrenaline rush markedly.
BEAT KAMMERLANDER/BARCROFT MEDIA/GETTY IMAGES

"Heeere's Johnny." Jack Nicholson helps you burn calories

WARNER BROTHERS/GETTY IMAGES

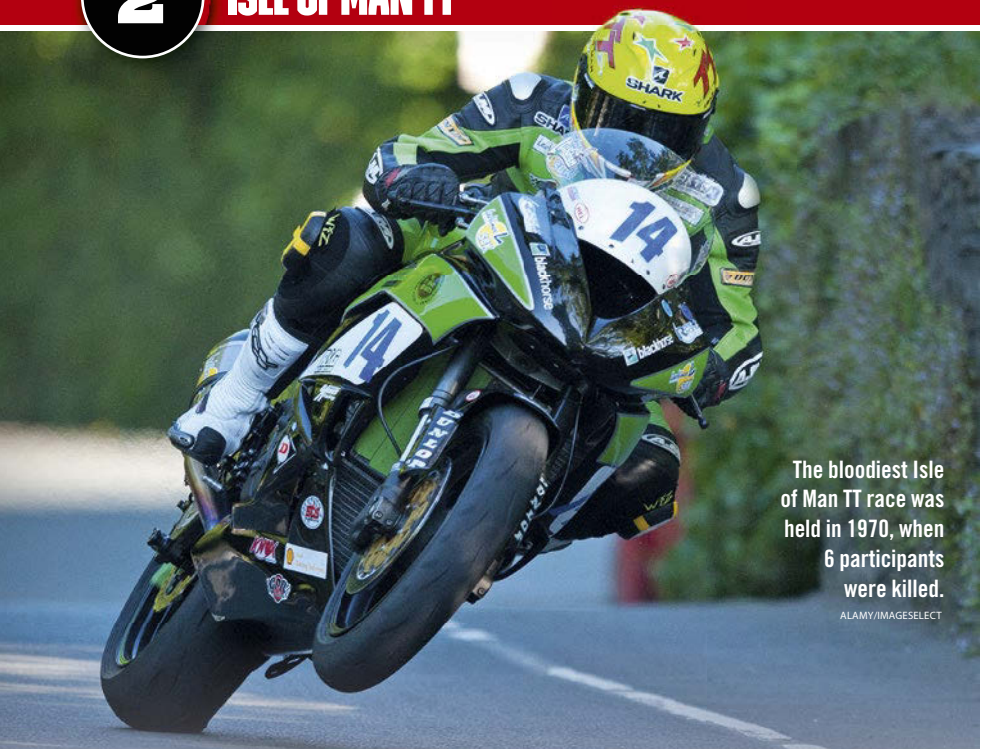
Thrillers stimulate slimming-down process

According to scientific research carried out at the University of Westminster, thriller films may have the same effect as bungy jumping. When Jack Nicholson shouts "Heeere's Johny" in The Shining, our bodies react as if we were in real danger. The shock effect makes the heart beat faster, and we absorb more oxygen. During the couple of hours that a horror film lasts, the body is so alert that it burns extra calories.

The 5 most slimming thrillers:

1. "THE SHINING": 184 calories
2. "JAWS": 161 calories
3. "THE EXORCIST": 158 calories
4. "ALIEN": 152 calories
5. "SAW": 133 calories

2 ISLE OF MAN TT



The bloodiest Isle of Man TT race was held in 1970, when 6 participants were killed.

ALAMY/IMAGESELECT

THE MOST DANGEROUS MOTOR RACE IN THE WORLD

Since 1907, the Isle of Man in the Irish Sea has hosted the notorious Tourist Trophy motorcycle race. Daredevils from all over the world flock to the island every year on two-wheeled, top-notch bikes to compete at speeds of up to 320 km/h on a 60 km route. At an average speed of some 200 km/h, the bikes rush though villages, past old stone dykes, and across mountains. The landscape is more fit for relaxing Sunday outings, but once a year, the island turns into a horror film. Approximately 250 people have been killed over the years – more than four dead participants per km.

▶ evolved since then, so today, we react in the exact same way, when we are overwhelmed by danger – or voluntarily seek it out.

SHAPED AS A PLANE WING

Peter straightens his back, forces his shoulders forward, and spreads his legs to activate the wingsuit. Air intake at the front sucks in air, inflating the membranes between his legs and under his arms. The purpose of the suit is to produce the biggest possible surface area, providing lift. Peter's hips are bent, and his head lifted, converting his entire body into a wing. He feels the lifting power of the air, as he steers closer to the rocky slope beneath him.

Peter feels completely ecstatic. The element of danger gives him a rush, a badly needed change from his monotonous, predictable everyday life at the office, and he feels free as a bird. His brain has been emptied of thoughts, and his body has been overcome and intoxicated by survival instincts.

MEN PRODUCE MORE ADRENALINE

The hypothalamus – also known as the control centre of the brain – registers that Peter is in a dangerous or stressful situation. Sensory impressions such as sounds, smells, pain, or visual impressions accumulate in this brain region, which sends signals through the nervous system to the adrenal medulla, ordering it to secrete adrenaline into the blood. The adrenal medulla functions as an adrenaline deposit and is a part of the sympathetic nervous system, which functions independently and outside the control of our willpower.

The concentration of adrenaline in the blood differs from person to person. Women generally produce less than men, whereas fit people produce more adrenaline than people who are in a poor physical shape.

Normally, adrenaline makes sure to keep the concentration of sugar and fat balanced within narrow limits. But if we are in danger or experience emotional pressure, we produce about 10 times more adrenaline. The extra hormones make the heart beat faster, and its blood vessels expand. The blood pressure increases, allowing the muscles to be ▶

Adrenaline dopes muscles and curbs the bowel function

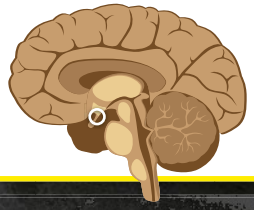
When the body comes under pressure, it reacts by producing large amounts of adrenaline. The hormone is pumped through the body with the blood, shifting the usual balance by stepping up some functions while curbing others.

SHUTTERSTOCK

THE PUPILS expand, and the vision is clearer.

THE BRAIN is tuned up with more blood.

1 **HYPOTALAMUS,** the command centre of the brain, uses sensory impressions to determine that you are in a potentially dangerous situation. Via the nervous system, it tells the adrenal medulla that you need help.



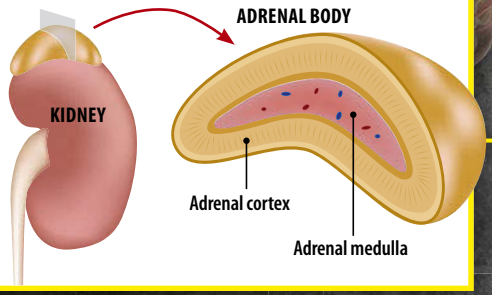
THE HEART beats faster and reacts more violently. Its blood vessels expand, so the heart can be supplied with more oxygen.

THE BRONCHI expand, allowing the absorption of as much oxygen as possible. The muscles use the extra oxygen to burn sugar and fat.

FAT DEPOSITS AND LIVER pump fat into the blood. Together with higher levels of cholesterol and glucose, fat functions as muscle fuel.

THE BLOOD VESSELS of bowels and skin contract, and digestion is put on hold. Instead, the blood is directed to vital places such as heart and muscles.

2 Adrenaline is produced in the **ADRENAL BODIES**; two glands the size of walnuts at the top of the kidneys. Adrenaline is a water-soluble hormone, which is produced based on the tyrosine amino acid, that converted adrenaline in the adrenal medulla. The hormone functions as a transmitter substance, determining the content of sugar and fat in the blood, etc.



3 **THE ADRENAL MEDULLA** secretes high levels of adrenaline, which is pumped through the body with the blood. In 1-2 seconds, the adrenaline affects its targets throughout the body.

THE PANCREAS pumps insulin into the blood. The insulin lends a helping hand to get glucose into the muscles, where it functions as extra fuel.

THE MUSCLES get more oxygen and glucose, making them stronger.

THE BLOOD clots more easily and coagulates faster to minimize blood loss in the case of haemorrhage.

4 The adrenaline binds to receptors on the surface of cells. **ADRENALINE RECEPTORS** exist on heart cells and muscle cells. When adrenaline binds to a receptor, a forceful signal is triggered inside the cell, which begins to burn lots of energy.

supplied with more blood. The blood vessels of the skin and bowels contract, as neither the digestive system nor the skin needs the blood, which can now flow to parts of the body where it is more useful.

Moreover, the adrenaline makes the airways expand and absorb more oxygen, and metabolism and blood sugar levels increase, feeding the muscles.

FEELS LIKE SUPERMAN

Like a huge flying squirrel, Peter speeds through the air. The wingsuit most of all resembles something from the early childhood of aviation, when daredevils and fantasists dressed in home-made suits jumped from structures, hoping to make history.

But whereas the aviation pioneers of the past were killed, modern adrenaline junkies like Peter are much more in control. The direction and altitude of the wingsuit is controlled by microscopic motion, as too much change of the suit's shape may cause an incontrollable spin. Even the slightest of motion may be fatal. Peter is completely focused and in control of every muscle.

He deliberately seeks out a dry river bed. His chest is only a few metres above the rough surface, as he rushes through the gorge at a speed of 150 km/h. The sight of the sparse vegetation is replaced by green, blurred light beneath him. Peter has completely lost his sense of time and place. He feels like Superman.

His body is one big muscle, boosted, dynamic, and invincible. He smiles to himself, as his cheeks flap in the wind. The sense of freedom is intoxicating, and though his ears are buzzing due to the wind, Peter can clearly hear his heart beat and feel the blood pulse through his body.

He is subjected to a tremendous jerk, as the parachute unfolds. The "brakes" are slammed, and Peter is forced upwards and backwards. Softly and comfortably, he glides through the air, as the surface of the Earth slowly comes closer.

Peter feels utterly relieved. The danger is no longer imminent, and the tension has been relieved. He looks up to watch the parachute sway above him like a tree canopy. His body starts to calm down. Now that he no longer needs to be on the alert, he breathes quietly. And a big smile spreads across his face.

> **Some people just cannot get enough and reach out for the adrenaline rush time and time again.**

SAME EFFECT AS COCAINE

Once the potential danger is gone, and the body no longer needs to be on alert, the organism shuts down its large-scale production of adrenaline. Three minutes after the tension was relieved, the concentration of adrenaline in the blood has already been halved, and after 30 minutes, the adrenaline level is back to normal. The organism regains its natural balance: The heart beats quietly, the breathing is normal, and the muscles relax – at least for a while. Some people just cannot get enough and reach out for the adrenaline rush time and time again.

An adrenaline rush is just like a cocaine or amphetamine rush. Both adrenaline and drugs increase the secretion of dopamine in the brain; a reward substance, which causes euphoria and well-being.

In some people, the state causes addiction and results in the development of tolerance – i.e. in order to obtain the same stimulating effect, the adrenaline junkie needs still bigger doses and so sets out in search of still more extreme and dangerous challenges.

One more thing: in this case, Peter is a work of fiction, but any resemblance the description of his jump and wingsuit has to any real life thrill-seekers you might know, is entirely intentional. SCI

3 BULL RUN

200-300 people are injured annually, running with bulls in the streets of Pamplona.

PABLO BLAZQUEZ DOMINGUEZ/GETTY IMAGES & INAKI VERGARA/SCANPIX

RUN WITH BULLS THROUGH NARROW STREETS

In the city of Pamplona in the north of Spain, the participants of the annual San Fermín Festival race with bulls through the city. The bulls weigh 500 kg each and are let loose on a stretch, which ends at the bull fighting arena.

The participants risk their lives, and every year, 200-300 people are injured during the race, as they fall or are trampled under foot. Some people even lose their lives. Since 1910, 16 men have been killed.

Artificial adrenaline restarts the heart

Medical adrenaline is made from tyrosine, which is converted into epinephrine (adrenaline) via chemical processes and can be injected into the body. The hormone protects against a number of disorders.

- By inhaling an adrenaline spray, **asthma patients** can expand their airways and ease their breathing.
- Local anaesthetics are added to adrenaline to make blood vessels contract. The blood flow of the affected area is reduced, making the effect of **the anaesthetics last longer**.
- Adrenaline stimulates the heart and makes the vessels contract. Doctors take advantage of this in the treatment of **cardiac arrests**, or if a patient's blood pressure suddenly plummets during surgery.
- In connection with bee stings, adrenaline can curb or eliminate critical **allergic reactions** such as heart failure or swollen airways.

The EpiPen is an adrenaline drug that can be injected into the body in case of allergic reactions.

MARTYN F. CHILLMAID/SCIENCE PHOT/SCANPIX

4 SPEED SKIING

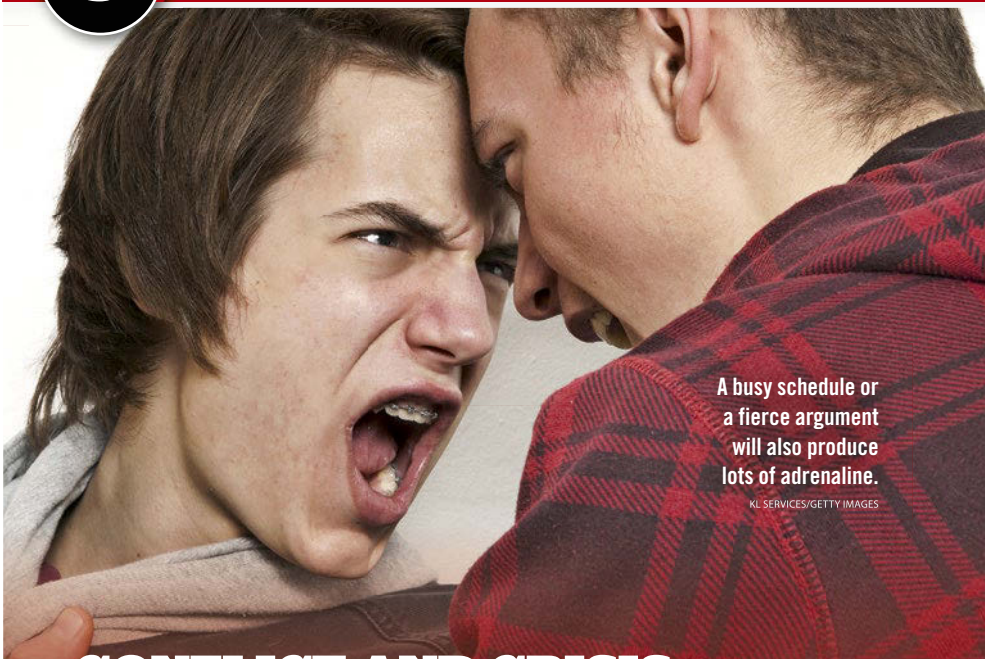
SKI DOWNHILL AT A SPEED OF 250 KM/H

If the black piste is no longer exciting,try speed skiing, i.e. skiing downhill in a straight line as quickly as possible. Often, the skis only touch the snow once every 20 metres, and the speed could be as high as 250 km/h. Professional speed skiers tie their forearms to their thighs to obtain better aerodynamics and prevent the air drag from making them unbend. The sport is dangerous, and one single moment of inattentiveness can cost the skiers their lives. Speed skiing is also known as "the fastest sport without an engine".

The speed skiing world record of 252.4 km/h was set in April 2014.

JERRY KOBALENKO/GETTY IMAGES

5 ARGUMENT



A busy schedule or a fierce argument will also produce lots of adrenaline.

KL SERVICES/GETTY IMAGES

CONFLICT AND CRISIS CAN ALSO PRODUCE A RUSH

While die-hard adrenaline junkies like risking their lives and experiencing danger, which others would never dream of putting themselves through, other adrenaline junkies manage to get their rush in less spectacular ways.

Instead of base jumping, they provoke drama in their lives, getting themselves into arguments and conflicts, putting things off until the last moment, arranging busy schedules, and never allowing themselves time to relax. In short, they thrive in a permanent state of stress, in which adrenaline pulses through their blood.

But if your body is subjected to high levels of adrenaline for long periods of time, the organism could be damaged, and you suffer a greater risk of blood clots, elevated blood pressure, arteriosclerosis, etc.

1% OF ALL HUMANS ARE IMMUNE TO HIV

French scientists have found two HIV-infected men who have miraculously cured themselves of HIV. Studies indicate that humans are developing resistance against one of the worst killers in the world.

AF MARC PROSSER

Wonder, headshakes, and raised eyebrows. A French group of scientists was in for a major surprise in 2014, when the members took a closer look at the results of a study of two HIV-infected men. Blood samples showed no signs of the dangerous HIV. The puzzled scientists carried out more detailed studies, scrutinising the men's DNA.

HIV can stick to a patient's DNA, but much to the surprise of the scientists, they discovered that HIV was surrounded by stop signals that locked the virus, preventing it from copying itself and infecting other cells.

HIV virus infects immune cells, destroying the immune system. But in a few patients, the cells resist the virus. CENUS LUNAU

The two HIV-infected men's bodies had found a clever way of capturing the virus and trapping it inside immune cells.

The discovery was not only surprising – the scientists also believe that the mechanism could possibly lead to the development of a cure against HIV and AIDS. According to the head of the group of scientists, Professor Didier Raoult, the human body's ability to combat HIV can be passed on by infected people to the next generations, conferring immunity to the virus. In fact, this could already have happened without scientists knowing about it.

1 % OF US CAN STOP HIV

The two HIV-infected men belong to a special group of people, who possess the special gift of being able to prevent – or at least strongly obstruct – HIV's ability to develop into AIDS. The group is known as elite controllers, and based on former studies and statistical calculations, scientists estimate that 1 % of all people are elite controllers.

However, the vast majority of HIV-infected people are unable to protect their bodies against the aggressive virus. Right after HIV infection, the virus is very active, efficiently destroying the immune system. HIV aims at the immune system's so-called auxiliary cells, whose job is to identify harmful, external microbes and inform other immune cells that the enemy needs to be combatted. Without the auxiliary cells, the immune system does not know what it is doing and cannot point out harmful viruses and hazardous bacteria.

> ***We believe that the human body can cure itself of HIV by endogenisation and that the mechanism protects against AIDS.***
>
> *Professor Didier Raoult, Inserm, France.*

HIV ATTACKS

HIV binds to the auxiliary cells via receptors on the surface of the cell. Receptors determine what is let in, and inside the cell, the virus cuts holes in the chromosomes, which are tightly coiled DNA. The virus deposits its genetic material, sealing the holes at both ends. HIV is now a part of the auxiliary cell's DNA, using the cell as a factory for mass production of virus particles. The production happens so fast that the cell burns out or explodes due to all the virus ▶

particles, which will destroy the person's immune system over time. That is the process taking place inside HIV-infected people who are not elite controllers.

But in the 1 % of all people, who are elite controllers, an immune cell protein known as APOBEC launches an extra violent counterattack. APOBEC prevents HIV's destructive ride through the immune system, which will end up killing the infected person. In the two men, APOBEC was much more active than it usually is – particularly around the time when they were infected.

CELLS LAUNCH COUNTERATTACK

The key to a cure against HIV and AIDS may be a particularly strong defence at the beginning of the infection, making the HIV's DNA mutate and be surrounded by stop signals.

One of the two elite controllers, who is now 57 years old, was infected with HIV, when he was treated for hepatitis. The

ANNE-CHRISTINE POUJOULAT/AFP/SCANPIX

"Our findings show that some people can absorb and neutralise HIV and perhaps pass the ability on to the next generation.

Research team leader & Professor Didier Raoult.

hepatitis drug probably boosts the cells' APOBEC production. Antibiotics treatment to combat the hazardous streptococcus bacteria also increases the production of the protective protein. APOBEC inserts errors in the HIV genetic material, so the virus can no longer convert the cell into a virus factory. The mechanism probably protects the patient against developing AIDS.

The 57-year-old elite controller was infected in 1985, but though he has never taken anti-HIV medicine, he is still going strong. The man was a drug addict in the 1980s and shared an injection needle with his HIV-infected girlfriend without developing any AIDS symptoms. The other elite controller, a 23-year-old man, who was infected in 2011, does not have any symptoms either.

According to Professor Raoult, the this hyperactivity can be stimulated by medication, turning anyone into an elite controller. This can either be done via gene therapy, by which scientists edit the genetic material, or by injecting overactive APOBEC proteins into the body.

8 % OF YOUR DNA IS VIRUS

The idea that we all have virus in our DNA may seem scary, but the phenomenon is not a rare one.

Up to 8 % of human DNA consists of inactivated virus, which has become part of the genetic material at some point and been passed on to the next generation via reproductive cells. According to Raoult, a cure against HIV is to be found in the human body's ability to absorb virus.

Scientists have still not found evidence of inactivated HIV having been passed on to the next generation. This would require the inactivated HIV virus to be located in reproductive cells. Nevertheless, Raoult believes that the passing on already took place in Africa, which represents the highest percentage of HIV-infected people. There, elite controllers could easily have passed the resistance on to their kids without scientists knowing it.

So, the French scientists are now studying a large number of Africans with the aim of developing new HIV drugs to curb the virus. SCI

MOST RECENT BREAKTHROUGH

VACCINE PROTECTS MONKEYS

Scientists are developing a **vaccine**, that blocks out HIV from immune system auxiliary cells. The vaccine protects against very high and continuous virus doses. The drug has been tested on monkeys, and the vaccine afforded protection for at least eight months, during which the monkeys were repeatedly exposed to HIV. The next step will be tests on humans.

HIV DELETED FROM DNA

With a new technology known as **CRISPR,** scientists are facing a possible breakthrough in scientific HIV research. Scientists have shown that they can cut out HIV DNA from the genetic material of humans, deleting the virus. The method removed all HIV genetic material from 72 % of the infected cells. More cell experiments in the lab must prove the CRISPR method's worth, before it is tested on patients.

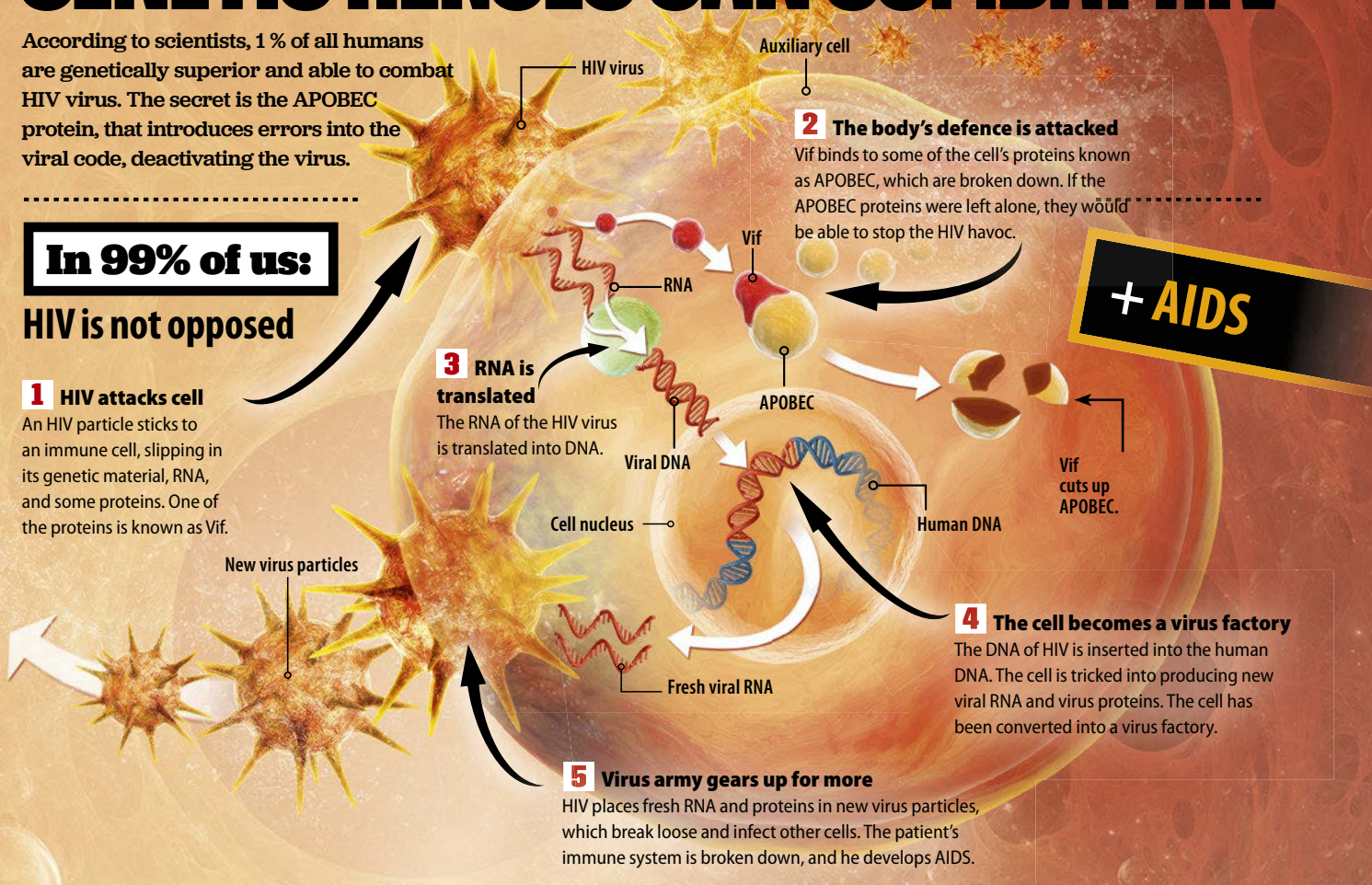
In experiments, a new vaccine protected macaques against HIV infection.
SHUTTERSTOCK

GENETIC HEROES CAN COMBAT HIV

According to scientists, 1 % of all humans are genetically superior and able to combat HIV virus. The secret is the APOBEC protein, that introduces errors into the viral code, deactivating the virus.

In 99% of us:

HIV is not opposed



1 HIV attacks cell
An HIV particle sticks to an immune cell, slipping in its genetic material, RNA, and some proteins. One of the proteins is known as Vif.

2 The body's defence is attacked
Vif binds to some of the cell's proteins known as APOBEC, which are broken down. If the APOBEC proteins were left alone, they would be able to stop the HIV havoc.

3 RNA is translated
The RNA of the HIV virus is translated into DNA.

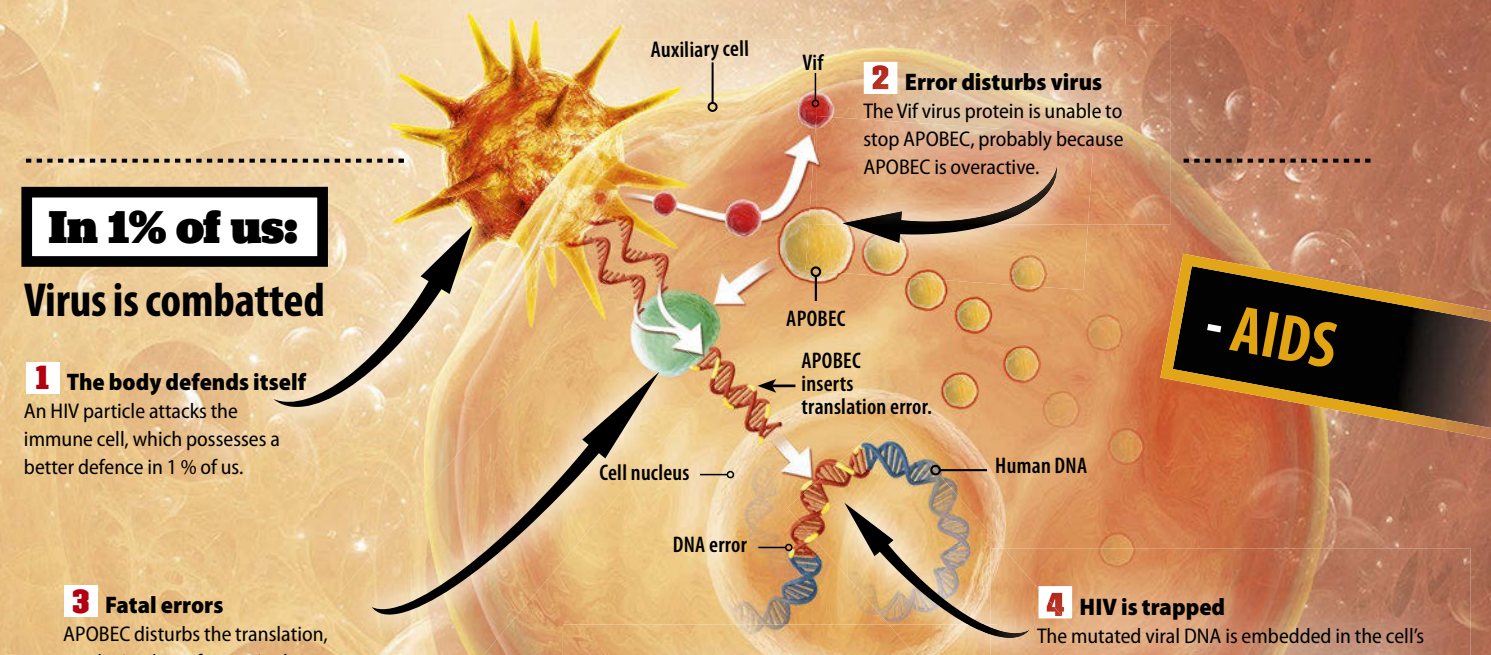
4 The cell becomes a virus factory
The DNA of HIV is inserted into the human DNA. The cell is tricked into producing new viral RNA and virus proteins. The cell has been converted into a virus factory.

5 Virus army gears up for more
HIV places fresh RNA and proteins in new virus particles, which break loose and infect other cells. The patient's immune system is broken down, and he develops AIDS.

+ AIDS

In 1% of us:

Virus is combatted



1 The body defends itself
An HIV particle attacks the immune cell, which possesses a better defence in 1 % of us.

2 Error disturbs virus
The Vif virus protein is unable to stop APOBEC, probably because APOBEC is overactive.

3 Fatal errors
APOBEC disturbs the translation, producing lots of errors in the copying from RNA to DNA.

4 HIV is trapped
The mutated viral DNA is embedded in the cell's chromosomes, but does not function properly.

5 The enemy is harmless
HIV is stuck. The virus can produce neither new RNA nor new proteins, so it can no longer spread throughout the body.

- AIDS

CLAUS LUNAU

TRIVIA

PUT YOUR KNOWLEDGE TO THE TEST

1. What is the largest dwarf planet we've discovered in the Solar System (so far)?

2. Inventor of a widely used alternative to petrol, this engineer disappeared at sea in 1913. His first name was Rudolf, his last was?

3. With their distinctive body-shapes, cellar spiders, crane flies and harvestmen are all commonly called by what single nickname?

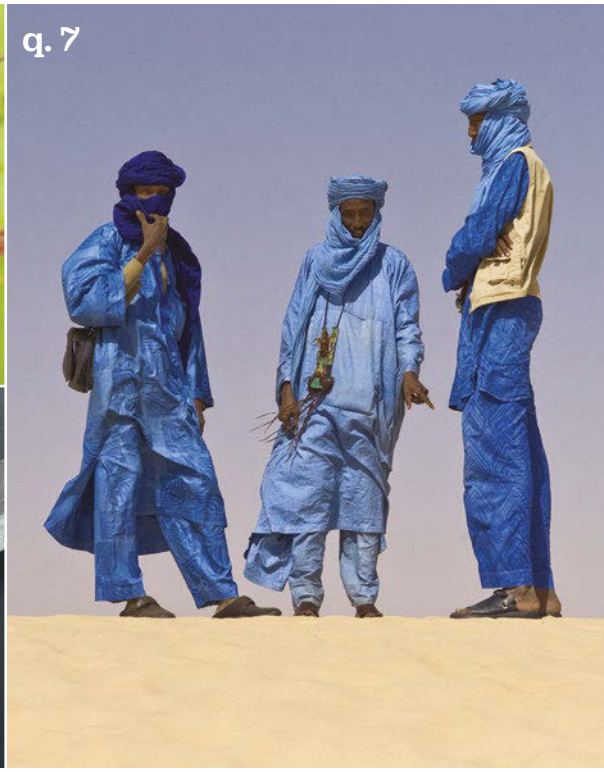
4. Built in 1947, the "Cathode Ray Amusement Device" could be considered the world's first what?

5. Cassette tapes used which of the fundamental universal forces to record 1980s synth pop in low-fidelity?

6. What would you do if you found a "pregnant" *Malus domestica*?


q. 3


q. 8


q. 7

7. These days, where do the Touareg people of the Sahara get high-quality steel to make their traditional swords?

8. The new HMAS Canberra is Australia's biggest warship. It's not an aircraft carrier, but an LHD, which stands for?

9. Which poisonous metal, liquid at room temperature, is also known as quicksilver?

10. True or false: a hobbyist microscope, worth a few hundred dollars, isn't powerful enough to see life in a drop of pond water?

ANSWERS ON p82!

Trivia Countdown (use fewer clues, get a higher score!)

	5 POINTS	4 POINTS	3 POINTS	2 POINTS	1 POINT
1. CHEMISTRY **Name this element**	The element is not found in a pure state in nature, and the metal was not isolated until 1807.	The element is located in group 1, period 3, of the periodic table.	Its positive ions are essential for the heart, metabolism, and nerve impulse of both animals and humans.	Together with chlorine, the element makes up a chemical compound known as table salt.	The element is the 11th on the periodic table. Its chemical symbol is Na.
2. ASTRONOMY **Name this craft**	The spacecraft was launched on its four day maiden voyage on 3 October 1985.	On its numerous missions, it spent more than 300 days in space, travelling over 200 million km.	The craft sent the Magellan and Galileo probes off towards Venus and Jupiter, respectively.	The spacecraft had four "sisters": Columbia, Challenger, Endeavour, and Discovery.	As part of the final Space Transportation System mission, it glided to land for the very last time on 21 July 2011.
3. MATHEMATICS **Name this geometrical figure**	The area of this figure is calculated as 0.5 times the sum of two sides multiplied by the figure's height.	The figure comes in two special versions: a right-angled one with two right angles and an isosceles.	The figure is a polygon – Greek for "many corners". To be more specific, it is a tetragon with four corners.	It has at least two parallel sides. If all sides are parallel in pairs, it is also known as a parallelogram.	The figure almost shares its name with a simple type of swing used by circus acrobats.

USE NEW TECH!

To read about new science and tech!

That's right, you heard right, the Australian Science Illustrated app is out now!
Plus, you can check out our other great science title Australian Popular Science.

WHY GO APP?

- ➡ **Save time!** Receive alerts when the next issue is out!
- ➡ **Save money!** Subscribe for even greater savings!
- ➡ Use your expensive tablet for **something more enriching** than tweets and recipes!

AVAILABLE NOW ON APPLE NEWSSTAND.

↳ Load the Newsstand store and search for SCIENCE ILLUSTRATED and POPULAR SCIENCE

INLAND ROBUST SCORPION
Scientific name: *Urodacus yaschenkoi*
Distribution: Central Australia, from Birdsville in the north to Broome in the west, and south into northern NSW.
Status: Not threatened.

PHOTOGRAPHY BY DAMON WILDER

DIG A HOUSE WITH HIDEOUS LIPS

When Europeans came to Australia in the late 18th century, naturalists and later biologists got to work cataloguing all the new species on this island continent.

At first glance, many Australian animals appear similar to European or African counterparts. Australia's burrowing scorpions, like this one, appear superficially similar to scorpions found around the world, so they were placed in the biological family *Scorpionidae*.

With the advent of genetic analysis and "cladistic" classification, it became apparent that Australia's scorpions aren't as closely related to old world species as first thought. So the sub-family *Urodacinae* got a promotion, bumping up to the level of family.

Scorpions like Yashenkoi here live in arid regions and hunt other arthropods, or indeed anything they can get their pedipalps on. They also build impressive burrows: a large adult Robust Scorpion can dig a tunnel that has multiple corkscrew turns, is up to a metre deep, and he can end up moving over 400 times his own weight in soil.

As perhaps fitting for a walking tank with a spring-loaded killing poison spike on the back, the scorpion does most of the digging with its chelicerae... which are the mouthparts that most closely correspond to our lips. That's tough.

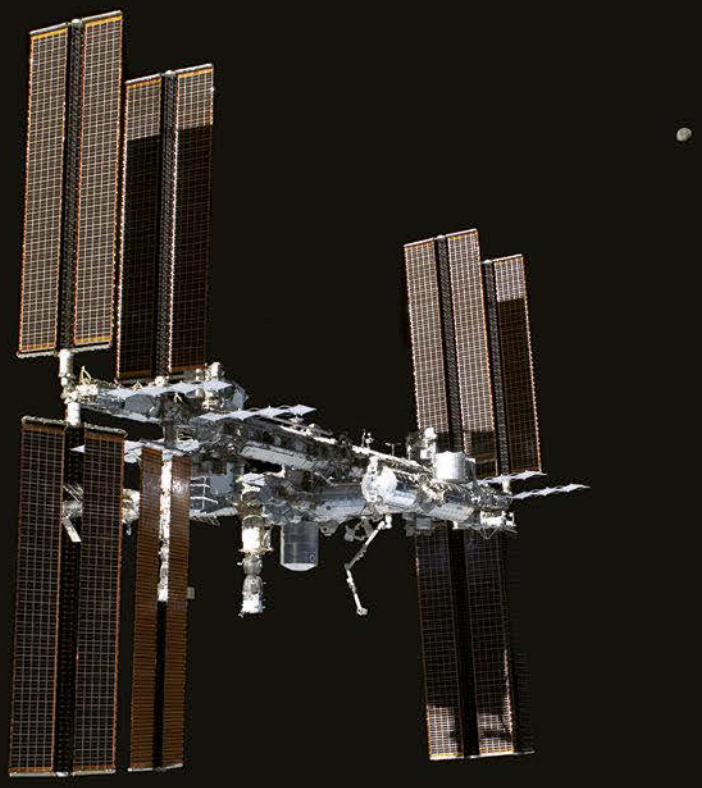
At up to 70 mm long, Inland Robust Scorpions make fascinating and long-lived pets. You can probably pick one up at your nearest exotic pet store for around $60, and expect it to live 10-15 years.

So just like a dog. Except not quite as huggable. SCI

VEXED BY VENOM

Scorpions use their distinctive tail to poison prey after first seizing it with their claws (which are actually specialised mouthparts called pedipalps). After repeated stabs, the venom subdues the struggling insect, lizard or occasional mouse. Because the sting is a hunting tool, the average scorpion probably won't use it against you in defence... unless of course you actually grab it or hold the animal in a closed fist. Australian scorpions can deliver a painful sting which can cause swelling or even numbness, but the venom is not powerful enough to kill a human. Unless you're one of the unlucky few who suffer anaphylatic reactions.

TRIVIA ANSWERS: 1. Eris. **2.** Diesel. **3.** Daddy longlegs. **4.** Videogame. **5.** Electromagnetism **6.** Eat its fruit (it's an apple tree). **7.** Toyota LandCruiser bumper-bars. **8.** Landing Helicopter Dock. **9.** Mercury. **10.** False! Try one out yourself!. **Trivia Countdown: Name this element:** Sodium **Name this spacecraft:** The Space Shuttle Atlantis **Name this geometrical figure:** Trapezium (or trapezoid).



THE SKY IS NO LONGER THE LIMIT.

The screens of the Future are available today!

Screen Innovations has worked with NASA to develop a one-of-a-kind, ambient-light-rejecting, zero-gravity screen to be installed in the International Space Station...

Until now, astronauts on the International Space Station communicated with Mission Control and their families back home on tablet-sized 13-inch displays. Now they will have a large roll-out screen from Screen Innovations, together with a laser projector that should last more than 30,000 hours of use – that's a movie a day for more than 40 years.

The criteria for a screen in space were unique, from the obvious need for extreme lightness and easy storage to trickier requirements such as screen rigidity in zero gravity and the ability to reject the bits of food and other detritus that have a habit of floating around zero-gravity environments.

Although the theatre in your home resides in a more-worldly environment with picture quality taking a front row seat it's nice to know that Screen Innovations also delivers the best down-to-earth solution around.

images courtesy: NASA

NAV
NETWORK AUDIO VISUAL

Network Audio Visual Pty Ltd
02 9949 9349 sales@networkav.com.au www.networkav.com

SI

screeninnovations.com/SPACE

PHANTOM 2 VISION+

YOUR FLYING CAMERA

The Phantom 2 Vision+ ushers in a new era of stability with an incredibly stable 3-axis gimbal. Combined with a sharp, powerful DJI designed camera it brings professional level aerial cinematography to everyone.

BONUS OFFER!

ONLY $2,249

DJI PHANTOM 2 VISION+ + HPRC Hardcase + SANDISK 32GB MicroSD

Bonus offer only available from the following participating dealers:

DigiDIRECT (1300 889 148) digidirect.com.au | **Ted's Cameras** (1300 768 833) teds.com.au | **Shepparton Camera House VIC** (03 5821 3855) camerahouse.com.au
Drone Zone Cannington, Gerry Gibbs Camera House WA (08 9451 8833) gerrygibbscamerawarehouse.com.au | **Leederville Cameras WA** (08 9242 1855) leedervillecameras.com.au
Georges Cameras NSW (02 9299 2323) georges.com.au | **Digital Camera Warehouse NSW** (1300 365 220) digitalcamerawarehouse.com.au | **Paxtons NSW** (02 8076 1903) paxtons.com.au

For reseller inquires please contact C.R. Kennedy: Email sales@crkennedy.com.au or Phone (03) 9823 1555